

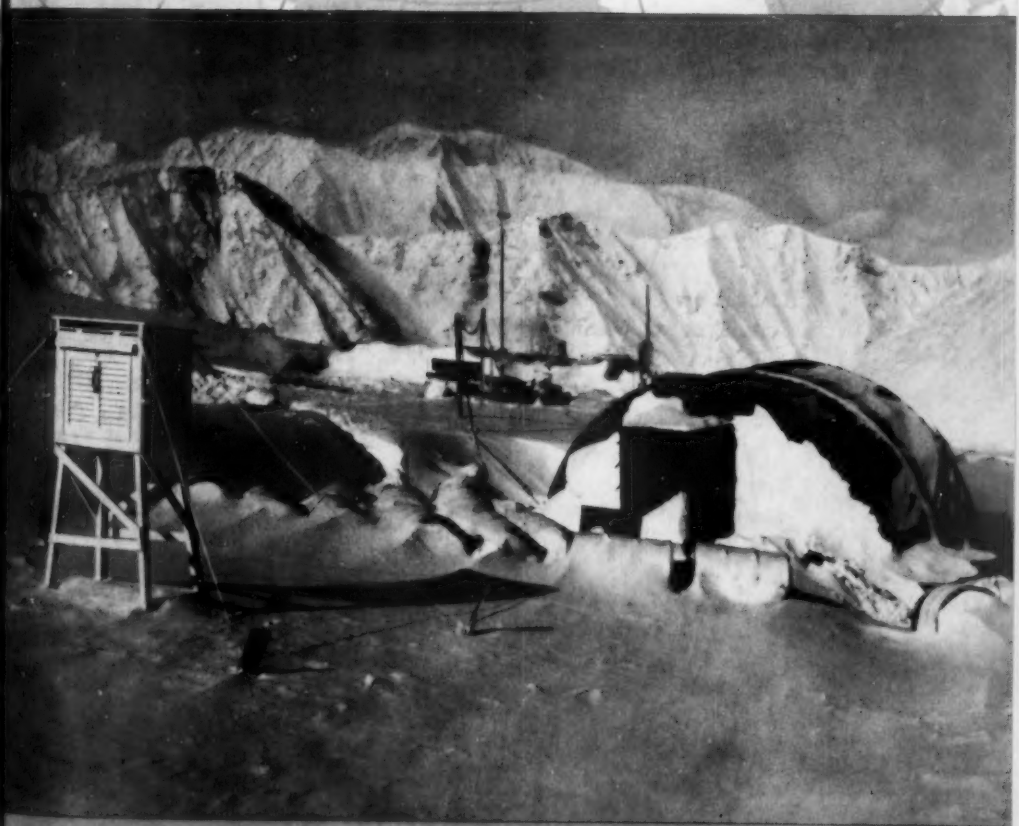
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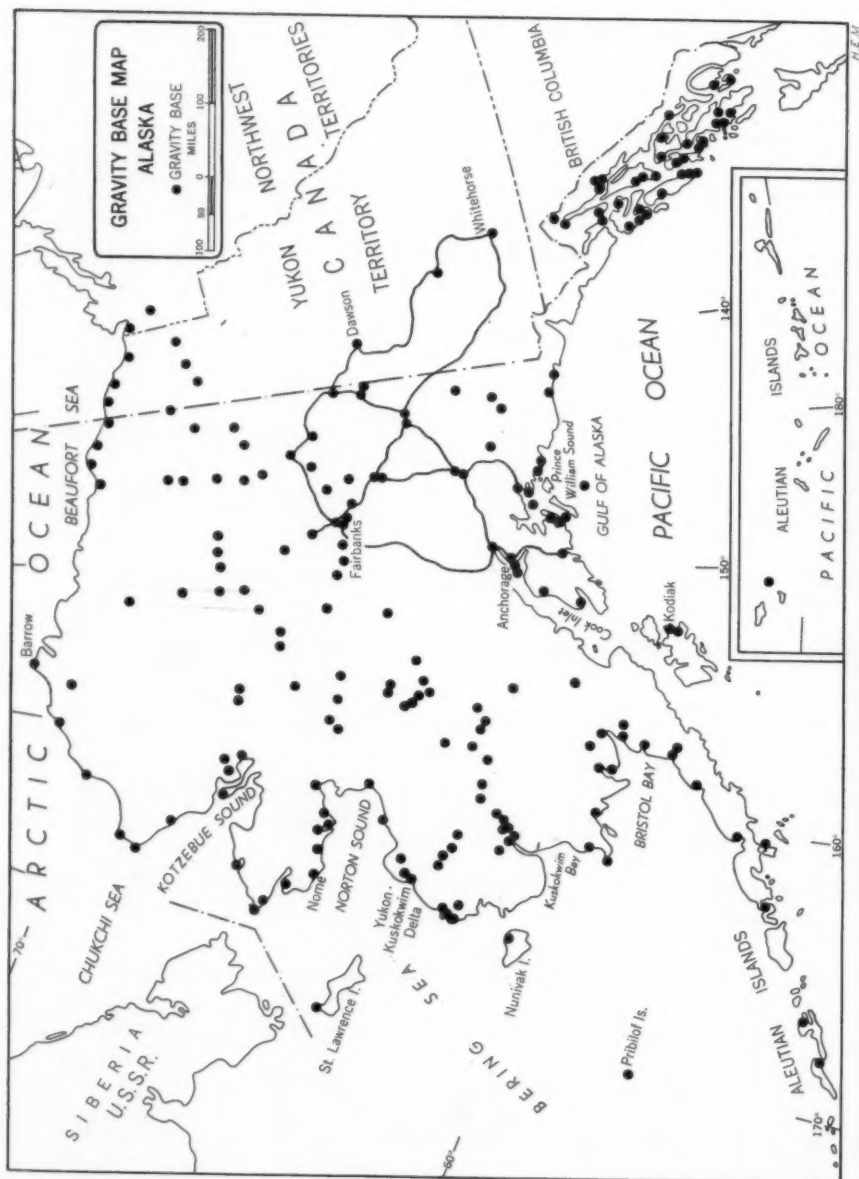


Fig. 1. Gravity stations and traverses.

## GRAVITY MEASUREMENTS IN ALASKA

E. Thiel\*, N. A. Ostenso\*, W. E. Bonini†, and G. P. Woollard\*\*

THE mapping of the earth's gravity field is important for several branches of scientific endeavour. In geodesy, gravity measurements furnish a basis for determining the overall shape of the geoid and its undulations. In studying the earth's crust gravity measurements provide a quick and reliable method of determining variations in crustal structure. In the study of the crystalline basement rock complex gravity values, used in conjunction with seismic and well data have immeasurably broadened our knowledge of both the lithology and configuration of this buried surface. Finally, such measurement have proved of great value in the search for mineral resources. The ultimate use made of gravity measurements depends on the method of analysis employed. The basic data for all uses are the same — the gravity observations themselves.

The present report outlines the extent of a gravity observation program in Alaska, carried out by the authors. Although the areal gravity mapping in this area will take many years to complete, sufficient work has been done to furnish a nucleus for integrating past and future studies into a unified network covering most of the state. Five hundred and thirteen gravity stations have been established to date distributed throughout Alaska as shown in Fig. 1. Approximately one-third are located at airports and the balance constitute traverses with a 5- to 10-mile station spacing following the highway system, the Alaska Railroad, and part of the Yukon River. Station descriptions and principal facts for the 513 gravity stations are presented in a mimeographed report (Thiel *et al.* 1958) of which the present paper is an abstract.

### Field procedure

In 1950 when the authors began their program of gravity measurements in Alaska little previous work was available. The U.S. Coast and Geodetic Survey had established only widely scattered pendulum stations and the limited oil exploration data were restricted to company use and based on an arbitrary datum.

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In beginning work in this new area it was necessary to establish base stations from which gravity-meter surveys could be carried, and to establish a uniform calibration standard for all gravity-meters to be employed in the work. To this end a line of precise gravity bases extending from Mexico City to Fairbanks was established by the University of Wisconsin with quartz-pendulum apparatus developed by the Gulf Research and Development Company. This work provided a gravity-meter calibration range of 4300 milligals and the necessary base stations in Alaska and the Yukon (Rose and Woollard 1956).

The second step in the program called for the establishment of subsidiary base stations throughout the state carefully tied to the primary bases (see Table 1). These subsidiary bases were established by air travel using long-range Worden geodetic gravity-meters calibrated against the Gulf pendulum standard. Financial considerations precluded chartering aircraft for this work. However, it was found that by using scheduled commercial flights and mail runs by Alaskan bush pilots to outlying Eskimo and Indian villages the cost of this phase of the program was not prohibitive. Since only 5 minutes are required to read a Worden gravity-meter, there was sufficient time at every stop to make the gravity observation while the pilot unloaded supplies. The only problem encountered was the occasional

Table 1. Primary base stations.

Place	Location	Latitude N.	Longitude W.	Altitude ft.	Observed gravity
Ladd Air Force Base, Fairbanks	South side of hangar No. 1, at base of control tower, adjacent to USCGC benchmark in face of tower and stamped "F 60 1951"	64°50.7'	147°36.2'	444	982.2437
<i>Area surveyed from base: Alaska north of the Alaskan Range and Yukon north of 65°N.</i>					
Elmendorf Air Force Base, Anchorage	Field entrance to MATS ter- minal (gate 2), on concrete platform level with the field.	61°15.0'	149°47.7'	212	981.9377
<i>Area surveyed from base: Alaska south of the Alaska Range and west of 141°W.</i>					
Juneau	Airport, at field entrance to passenger terminal, on left- hand concrete sidewalk (as one faces terminal), at the end of sidewalk, nearest runway.	58°21.7'	134°35.3'	26	981.7672
<i>Area surveyed from base: Southwest Alaska.</i>					
Whitehorse	Airport, in the basement of emergency pumping station of Dept. of Transport, about 100 ft. east of C.P.A. hangar.	60°43.0'	135°03.4'	2281	981.7487
<i>Area surveyed from base: Yukon south of 65°N.</i>					

difficulty in finding a suitable site that could be adequately described for reoccupation by later observers. Approximately 12,000 miles were flown in single-engine aircraft in carrying out this phase of the program. This constituted about 90 per cent of the mail runs scheduled by the Civil Aeronautics Authority at the time.

Phase three involved gravity observations at 5- to 10-mile intervals on the ground by whatever means of transportation were available. Gravity observations were taken during travel along the Alaska, Richardson, Anchorage-Palmer, Glenn, Slana-Tok, Elliot, Steese, and Taylor highways. The Department of the Interior provided a track sedan for travel along the Alaska Railroad between Fairbanks and Seward. The U.S. Army Arctic Center provided boats and manpower for an 800-mile river trip down the Lewes and Yukon rivers from Whitehorse to Circle. In Table 2 are listed the observers, the instruments employed and their calibration, and the year of completion of these various aspects of the program.

Table 2. Establishment of stations.

Observer	Gravity-meter	Calibration	Year
J. C. Rose	Gulf pendulums		1953
W. E. Bonini	North American 113a	0.21289 mgls./dial unit	1950
C. Muckenfuss	Worden 10-e	0.02296 mgls./vernier unit	1950
E. Thiel	Worden 14-c	0.10326 mgls./vernier unit	1954
N. A. Ostenso	Worden 14-d	0.12599 mgls./vernier unit	1955
E. Thiel	Worden 14-d	0.12599 mgls./vernier unit	1955
E. Thiel	Worden 147	0.010456 mgls./vernier unit	1956

### Reduction of data

Observed gravity values are on the Potsdam standard, which gives a value of 980.1190 gals for the United States national gravity base at floor level in the gravity vault of the U.S. Coast and Geodetic Survey in the Department of Commerce Building, Washington, D.C. (Woollard 1958). Station latitudes and longitudes were taken from the U.S.G.S. Alaska Reconnaissance Topographic Map Series, scale 1:250,000. Altitude control has been derived from a multitude of sources of varying accuracy (Table 3).

The three values of observed gravity, latitude, and altitude are the data from which various gravity anomalies can be computed. In the present study only Free Air and Bouguer anomalies have been determined. This was done at the University of Wisconsin using the IBM 650 computer in the Numerical Analysis Laboratory. The 1930 International Gravity Formula has been used as the basis for computing theoretical sea-level gravity. In order to obtain the maximum geological value from the data Bouguer anomalies were computed for densities of 1.77, 2.00, 2.20, 2.40, 2.50, 2.67, 2.80, and 2.90 at each station. No corrections for terrain or gravity tidal

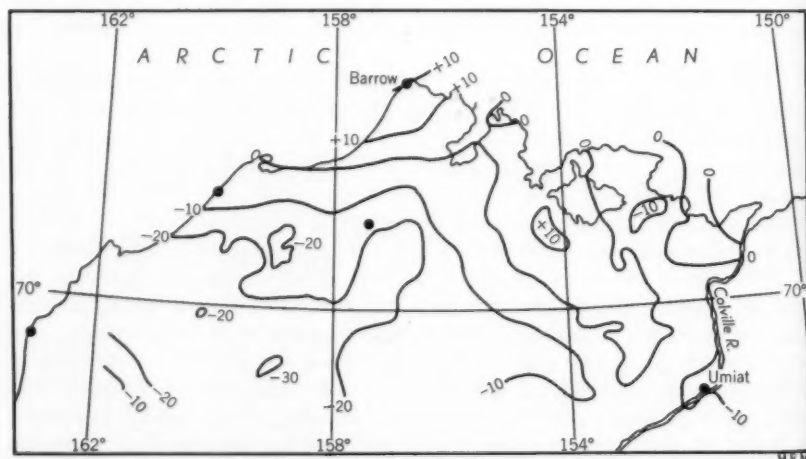
**Table 3.** Sources of altitude control.

<i>Estimated accuracy</i>	<i>Source of control</i>
$\pm 1$ foot	Benchmark or levelling from that
$\pm 2$ feet	Altitude given for U.S. weather station mercury barometer
$\pm 3$ feet	Estimated from mean sea-level with tidal correction from tide tables
$\pm 5$ feet	Altimeter
$\pm 25$ feet	C.A.A. altitude for runway
$\pm 25$ feet	Based on computed river gradient between points of known altitude
$\pm 100$ feet	U.S.G.S. Alaska Reconnaissance Topographic Maps, scale 1:250,000

effects have been made, since the magnitude of these corrections is no larger than possible altitude errors. Because of the questionable altitudes of some stations the observed gravity values are of a higher order of accuracy than the anomaly values.

### Results

*Areal gravity coverage.* The gravity coverage in Alaska at the present time does not permit a realistic anomaly map to be constructed for the state as a whole. However, for two areas reasonably accurate regional anomaly maps are presented. Fig. 2 is a map of the Naval Petroleum Reserve No. 4 in northwestern Alaska. This area was originally mapped in detail by United



**Fig. 2.** Bouguer anomaly map (density = 2.67) of Naval Petroleum Reserve No. 4, Northwestern Alaska.

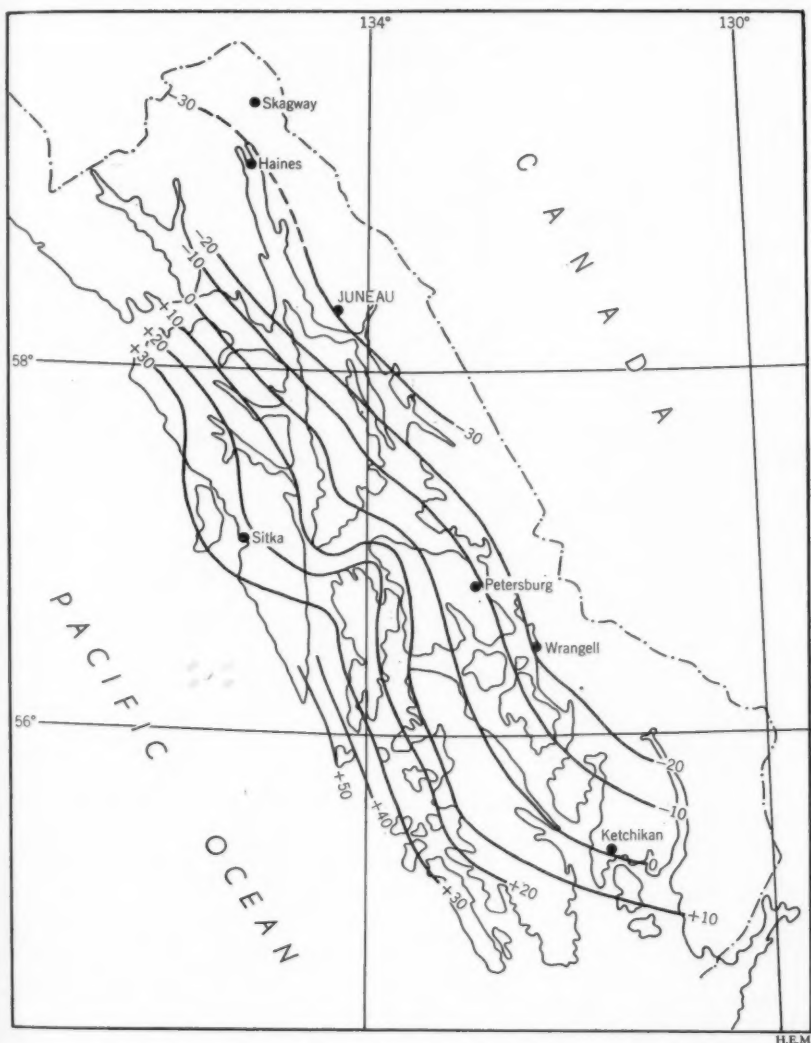


Fig. 3. Bouguer anomaly map (density = 2.67) of southeastern Alaska.

Geophysical Company under contract to the U.S. Navy on an arbitrary datum. Values have been adjusted to conform to the Potsdam datum.

Fig. 3 is a regional gravity map of southeastern Alaska. The prominent decrease in anomaly as one proceeds inland perpendicular to the coast is immediately evident. The magnitude of the gradient suggests a thickening of the earth's crustal layer, or, in seismic terms, a downward dip of the Mohorovicic discontinuity as one proceeds from ocean to continent. Superimposed on this regional trend between Sitka and Petersburg is a more local

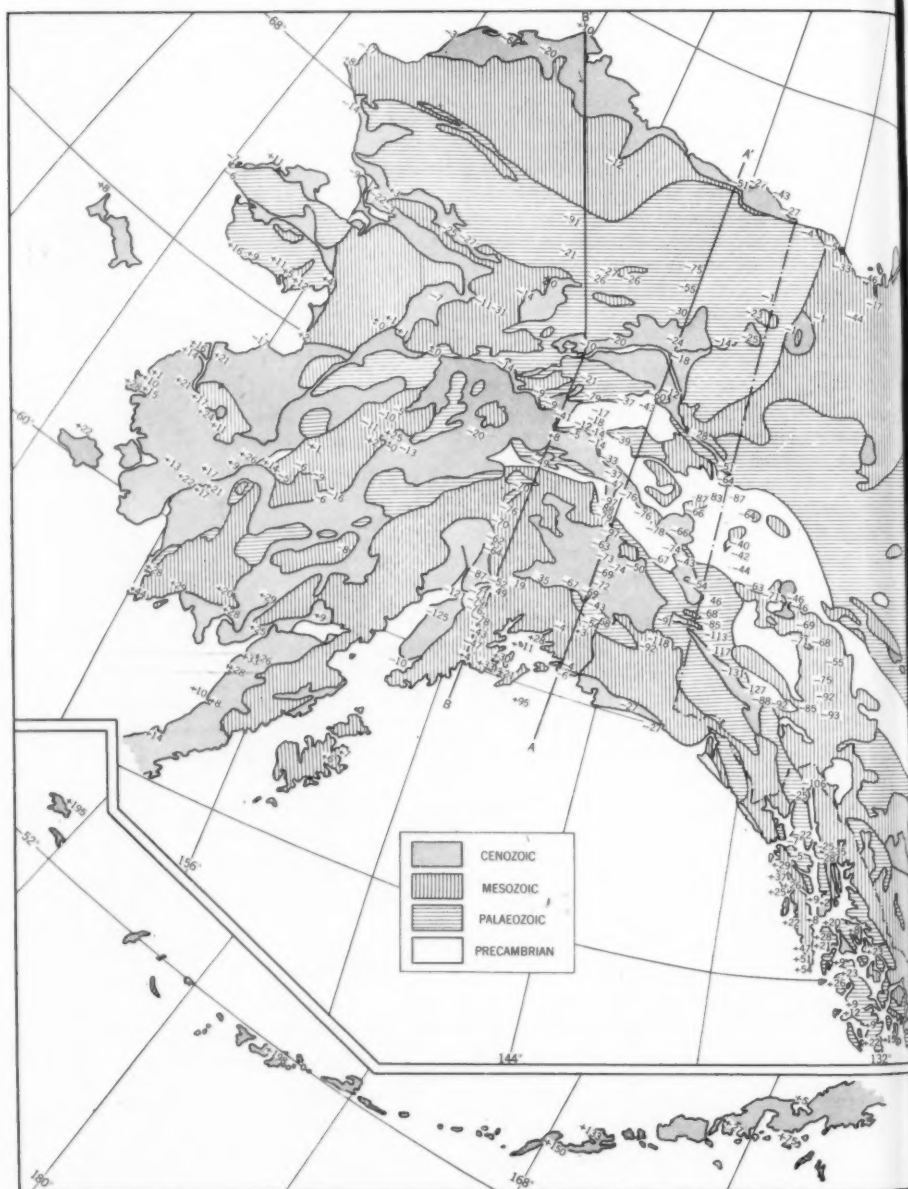


Fig. 4. Generalized geological map of Alaska with superimposed Bouguer anomalies (density = 2.67).

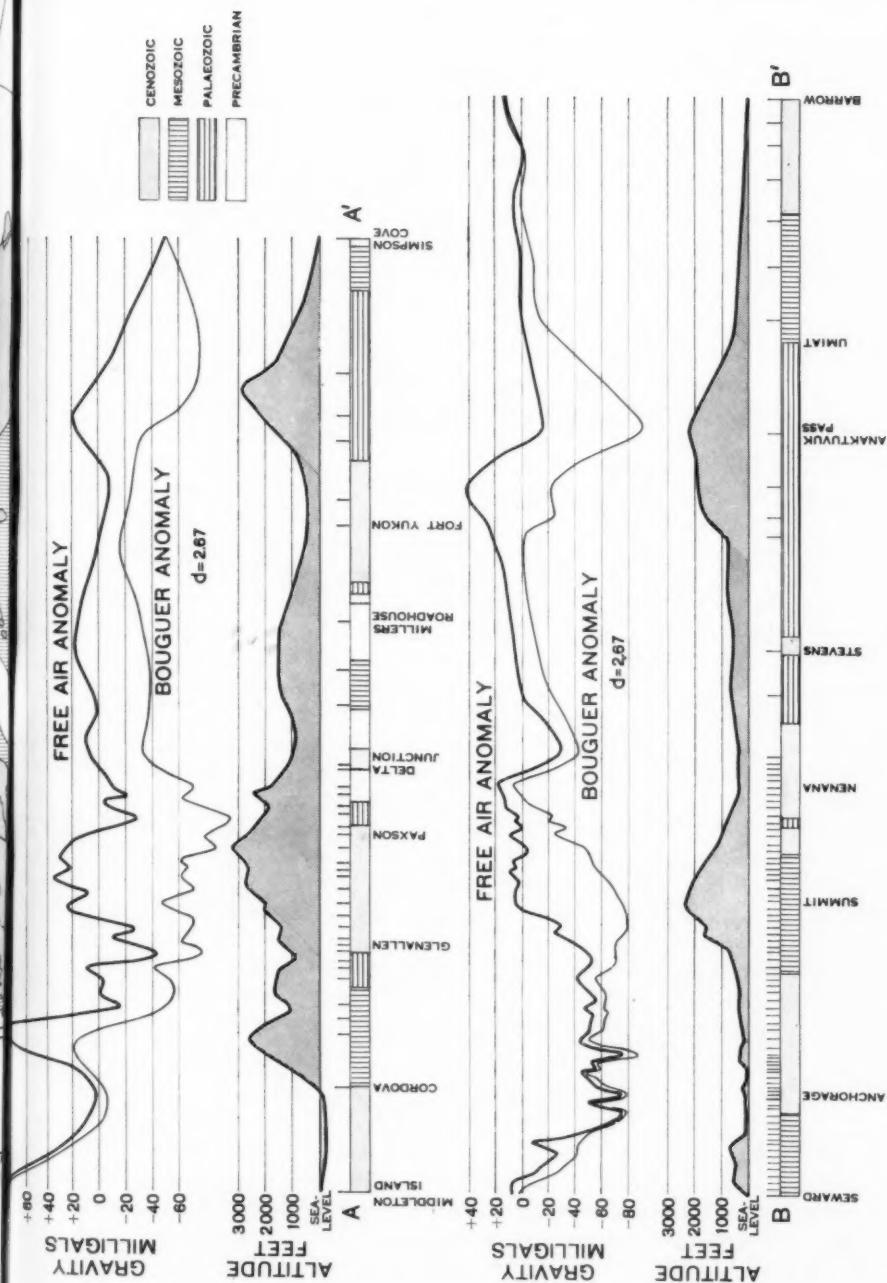


Fig. 5. Free air and Bouguer anomaly profiles in relation to topography and geology.

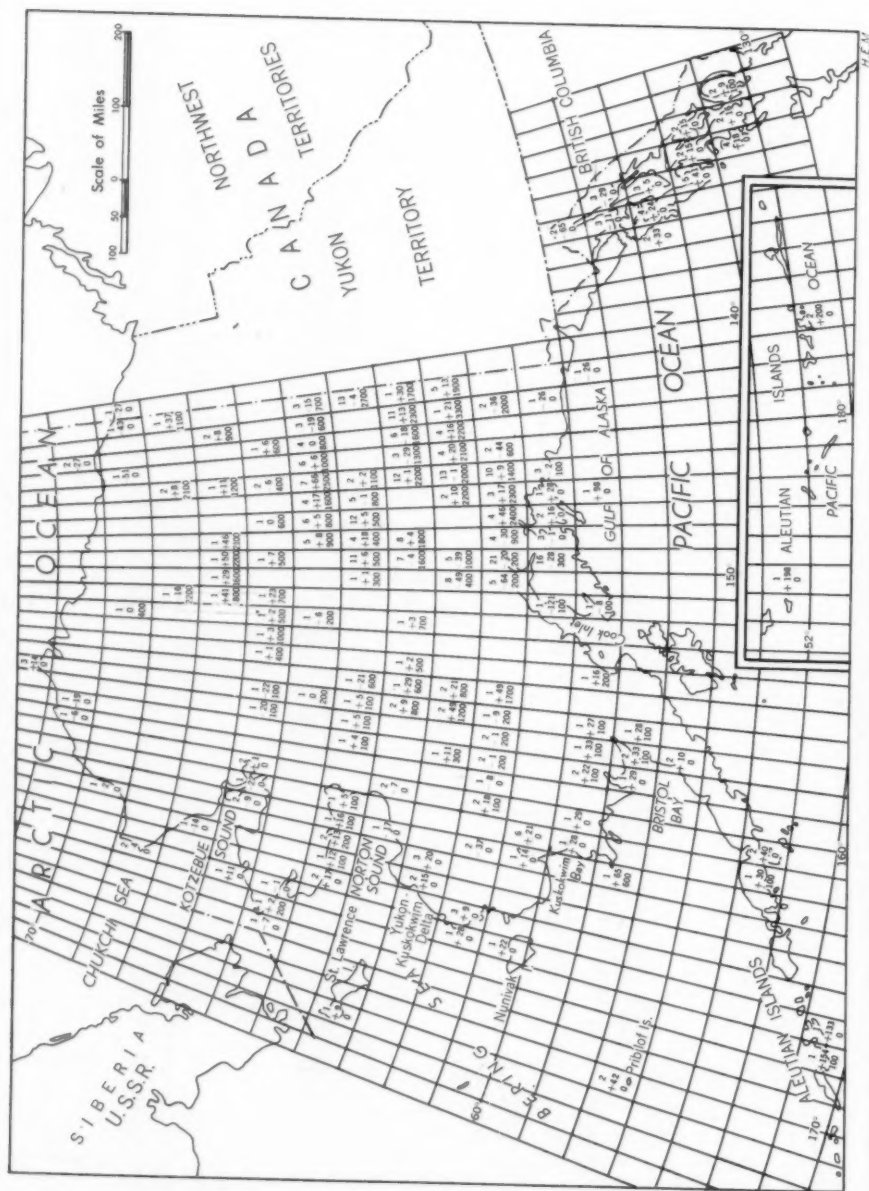


Fig. 6. Free air anomalies in  $1^\circ$  by  $1^\circ$  rectangles. Figures give (a) number of gravity observations per rectangle, (b) mean free air anomaly, (c) mean altitude of gravity stations.

anomaly of near surface origin. The anomaly gradient from Haines northward through Skagway is particularly steep.

*Geology.* Fig. 4 is a generalized geological map of Alaska with Bouguer anomalies (density = 2.67) superimposed. The most pronounced features are the following:

- (1) A great gravity low occupies Cook Inlet, with anomalies for sea-level stations of  $-125$  milligals. By contrast, other coastal embayments are either positive (for example, Prince William Sound and Bristol Bay) or nearly zero (Norton Sound and Kotzebue Sound). The Cook Inlet low is the most striking anomaly on the Alaska gravity map and calls for a thorough study by both the geophysicist and the structural geologist.
- (2) Positive Bouguer anomalies of nearly 200 milligals occur over the Aleutian Chain. Such large positive anomalies are not the rule, although positive anomalies of 100 milligals are found on some recent volcanic islands. Isostatic theory requires the gradual sinking of the islands once the volcanic outpouring is complete.
- (3) An average positive anomaly of 17 milligals occurs on the Yukon-Kuskokwim delta. If the earth's crust were rigid and capable of supporting great loads, large positive anomalies would be expected in areas of recent deposition. The lack of such anomalies would indicate that isostatic adjustment is proceeding concomitantly with deposition.
- (4) An anomaly of  $+7$  milligals centres on Nenana. Positive Bouguer anomalies are not common in the continental interior and are usually associated with the presence of high density rock at or near the surface.

Fig. 5 presents a graphic comparison of gravity, topography, and geology along two north-south sections perpendicular to structural strike. The vertical lines above the geology indicate gravity stations; control for the northern half of each profile is scanty. The two profiles exhibit negative Bouguer anomalies over the Alaska and Brooks ranges in accord with isostatic theory. The Cook Inlet low and the Nenana high are both evident on profile B — B'.

*Geodesy.* For the determination of the undulations of the geoid the geodesist would like to know the mean value of the free air anomaly for each  $1^\circ$  by  $1^\circ$  rectangle on the earth's surface. These basic data for Alaska are still incomplete, but all present knowledge is included in Fig. 6. The empty rectangles are mute evidence of the need for additional gravity observations.

#### Acknowledgements and request

The gravity work reported in this paper was supported in part by the Cambridge Research Center of the U.S. Air Force. However, much of the field work was a "labour of love" and resulted from individual initiative in securing transportation and a willingness to work for expenses only or entirely gratis.

Fig. 6. Free air anomalies in  $1^\circ$  by  $1^\circ$  rectangles. Figures give (a) number of gravity observations per rectangle, (b) mean free air anomaly, (c) mean altitude of gravity stations.

The authors would appreciate receiving additional Alaska gravity data as they become available through commercial exploration ventures, academic research projects, and other work. It is their hope to gather these data as they accumulate, with the objective of finally compiling an accurate gravity map of Alaska. The present paper is only the first step.

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## THE McCALL GLACIER PROJECT AND ITS LOGISTICS

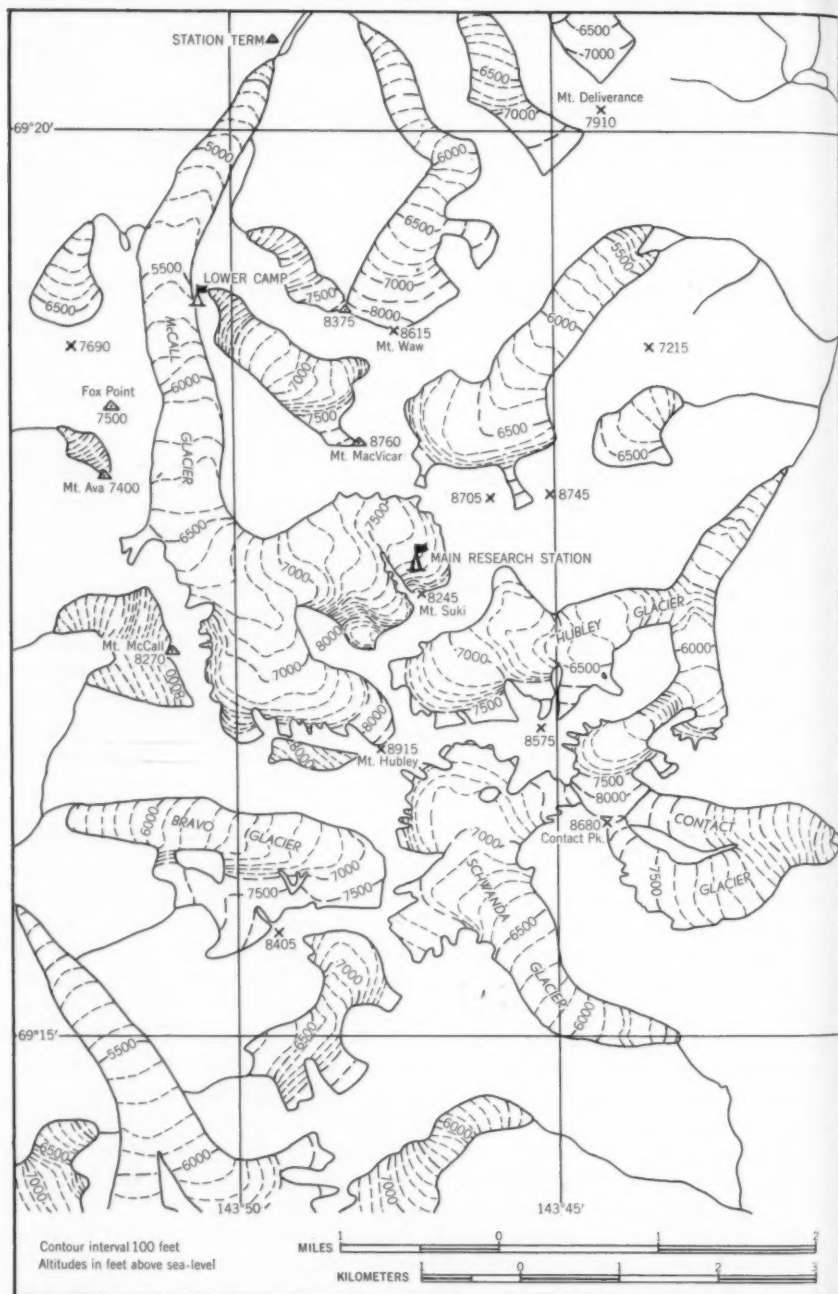
Robert W. Mason\*

### Locating a suitable glacier

IN August 1956 after the United States I.G.Y. Glaciological Panel had decided to organize a glacial-meteorological project in the Romanzof Mountains of the eastern Brooks Range, the writer accompanied Dr. Walter A. Wood, the Project Director, and the late Dr. Richard C. Hubley, the then Project Chief Scientist, to northern Alaska. We hoped to find in the highest area of the Brooks Range, around  $144^{\circ}\text{W}$ . and  $69^{\circ}30'\text{N}$ ., a valley glacier that would lend itself to a micrometeorological and glacier-movement survey program that could be undertaken during the International Geophysical Year. The Romanzof Mountains support the most significant group of glaciers in the Brooks Range, with a cumulative glacierized area of perhaps 260 sq. km. The glaciers lie generally above 1,500 m. among a group of peaks of heights between 2,290 m. and 2,740 m. above sea-level, and are thermally sub-polar.

One of the first requirements before any program planning could begin was to find if any of the glaciers in this unfamiliar region were reasonably accessible. Approaching the area that interested us proved remarkably easy. As I.G.Y. personnel the party were offered the use of an Air-Force C-47 to transport them from Fairbanks to the small Indian community of Bettles, 180 miles to the north and one-third of the distance to the Romanzof area, but we could have travelled on one of the regular scheduled airline flights that radiate from Fairbanks to all major settlements in the north of Alaska. In order to reconnoitre conveniently the Mt. Michelson area of the range, it was necessary to establish a camp at Lake Schrader within an hour's flying distance from the mountains. Facilities for this were available at Bettles: a pilot who knew the country well, and a suitable airplane. Within 5 hours after having strapped ourselves into a Cessna 180, an all-metal three-passenger float-plane, the party were encamped at the lake. After another hour in the air from Lake Schrader an ideal glacier for the scientific program had been located: McCall Glacier, a slender valley glacier with a gentle gradient, no ice falls, limited crevassing, and no tributary cirque glaciers. The glacier terminus lay almost at the frontal scarp of the mountains. This meant that the glacier could, if necessary, be approached

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on foot from a low camp on the tundra, that a light plane on ski could probably land on the glacier without difficulty, and that perhaps vehicles could be driven up the valley to transport fragile supplies to a glacier camp site (see Fig. 1<sup>1</sup>).

### Logistical problems

The logistical problems of the McCall Glacier Project proved to be simple for several reasons. First, the U.S. Air Force had agreed to drop the bulk of fuel and supplies on the glacier and resupply the camp during the 18 months of the I.G.Y. Without the organization and special equipment of the Air Force in Alaska, depositing 34 tons of fuel and 18 tons of supplies and rations for four men would have been a major obstacle for a field party that had to rely on commercial transportation.

Second, although commercial airlines do not have the facilities for this kind of large-scale operation, they can put men and equipment anywhere in Alaska efficiently and with minimum risk, because they employ many pilots who are experienced in flying small aircraft, and who know intimately the country over which they fly. Even though the three pilots who have flown for this project had never landed on a glacier before 1957, they had an average of 8 years' experience with all other types of arctic terrain and quickly became proficient in operating from a glacier surface. These pilots have demonstrated to many skeptics that glacier flying can be as safe an operation as any other.

After the initial reconnaissance in 1956 the project planning went ahead with the assurance that station components would be parachuted to the site. The problem of moving personnel and delicate apparatus to the glacier and relieving staff members periodically hung on the adaptability of ski-equipped light planes. Without this air transport it would have been necessary to use tracked vehicles or back-packing to move from a low-level site on the tundra all material that could not be dropped.

In April 1957 a low-level camp was established at a small lake 10 miles from the glacier terminus. Later this camp was to be completely outfitted to serve the glacier party as an emergency retreat and to be used as a summer station by other field workers. Next, a landing was made on the lower part of the glacier. The glacier surface, very smooth, with only a small accumulation of wind-packed snow in most places, and areas of bare ice, made an excellent landing field after it had been marked with flags.

Since it was necessary to establish not only a camp near the glacier terminus for use by the surveying party in summer, but also a main camp for the meteorological station as high as possible in one of the three cirques feeding the glacier trunk, another landing had to be attempted 3 miles

<sup>1</sup> The figures illustrating this and the following two papers have been numbered consecutively for ease of reference.



Fig. 2. View looking east to southeast into the three cirques at the head of McCall Glacier. The small dot in the right half of the uppermost (left) cirque is the main station. The peak beyond the lowest (right) cirque is Mount Hubley, 8,915 feet (2,717 m.).

farther up the glacier in a more confined bowl with a steeper slope. The landing was accomplished successfully and has been repeated many times (see Fig. 2).

In the first week of May 1957 C-119 cargo planes of the U.S. Air Force dropped the prefabricated buildings, rations, and fuel on the head snows of McCall Glacier. The four-man party erected a temporary camp below the drop area and began assembling the five half-units of Jamesway huts that were to serve as buildings for the upper station. Within 6 days two Jamesway huts had been erected on a levelled area of firn, the remaining half-unit was set up to house the diesel light plant, and the provisions sledged into camp.

A few days later the first load of instruments was flown from Barter Island, 50 miles to the north, and landed only 300 feet down slope from the station. The plane was used also to move equipment from the lower glacier camp to the high station.

By June 13 both glacier camps were completed. Micrometeorological instruments were in place and working. The 100-watt radio linking the glacier with all other radio stations in north-central Alaska was operating. A 3-month supply of fuel and rations was cached at the camps and the scientific program was at last fully under way.



Fig. 3. View down glacier from west ridge of Mount Hubley. Note hanging glacier in right middleground, avalanche tracks in left foreground, and ski tracks in right foreground.

## GLACIER STUDIES OF THE McCALL GLACIER, ALASKA

John E. Sater\*

**T**HE McCall Glacier is a long thin body of ice shaped roughly like a crescent. Its overall length is approximately 8 km. and its average width about 640 m., making an area of 5.12 sq. km. The highest reaches of the ice are on the north-facing walls of the upper valley in cirques at an altitude of over 2,700 m. above sea-level. The altitude of the terminus is 1,250 m. (see Fig. 1).

The main camp with the micrometeorological and climatological stations lies at an altitude of 2,318 m. on a shelf in the highest cirque. Situated 2.41 km. from the terminus on a lateral moraine is the lower camp, which is used during the summer as base for the ice-motion studies and geological reconnaissance.

The drainage basin of the McCall Glacier is a very well defined area, of which the upper two-thirds are filled by the glacier itself. The walls of the basin consist mostly of loose rock talus, with a few bed-rock faces, as for instance along the southwest rim. Their exposures or pitch are such that they do not retain snow throughout the year.

The lower part of the basin does not now contribute to the regimen of the McCall Glacier. Whereas there are vestiges of former glacial activities in two small, probably stagnant cirque glaciers and a more active (based on quantity of dry calving) hanging glacier (see Fig. 4), which flows down the north face of Mt. MacVicar, the only connection these features have at present is through the marginal meltwater channels of the McCall Glacier. The broadening of the lower basin is indicated by the fact that the ridges defining the area are not visible from the glacier itself.

The outline of the rock walls causes the ice in the highest cirque to flow west, 150 m. lower the ice joins a smaller source, another 180 m. lower it meets the ice from the lowest cirque and then turns sharply, to assume finally a northerly flow. The lowest cirque has the largest area, but its gradient is relatively small and its contribution to the total flow appears less than might be expected. However, the individual contribution of each cirque has not yet been determined (see Fig. 2).

From the confluence of the cirques the ice drops 730 m. in eight broad steps to the terminus. The surface slope of the risers of the steps ranges up to 15 degrees and that of the benches or treads is seldom more than 3 degrees (see Fig. 3).

\* Junior Scientist, Arctic Institute, 1958.

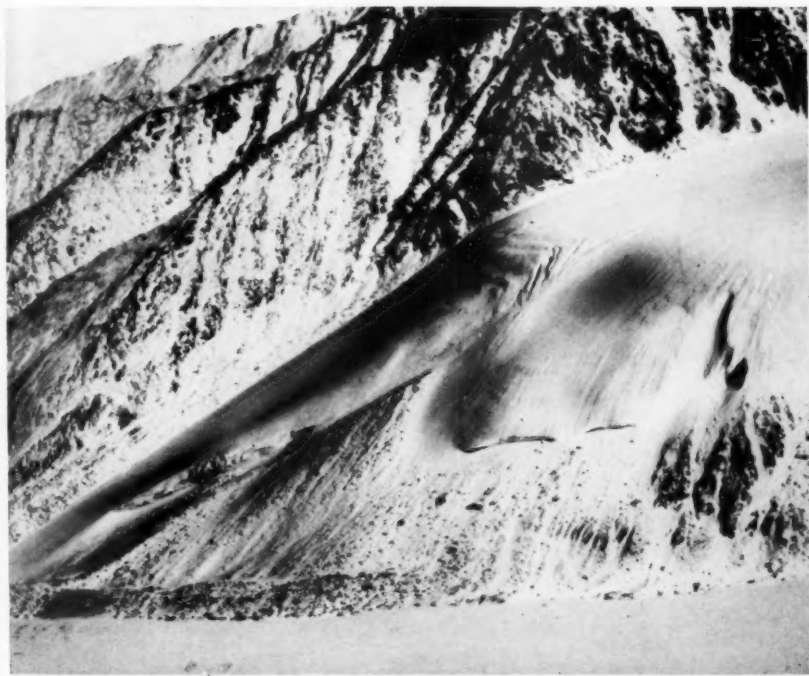


Fig. 4. View of hanging glacier from west ridge. Lower camp is the small dot on left half of lateral moraine.

Three of the highest peaks of the area are located along the east side of the cirques and they, as well as most of the prominent peaks surrounding the glacier, rise 520 m. above the ice surface. This barrier, in combination with the open vista to the west and the prevailing southwest winds, has an important influence on the weather conditions at the high camp. The full exposure of the camp has the consequence that observations of temperature and wind are more indicative of regional behaviour of the air than they would be elsewhere on the glacier. The barrier to leeward also causes downdraughts and general turbulence in the cirque, and occasionally reinforces the drainage wind that flows down the glacier.

Much of the same behaviour of the air was seen at the lower camp, the position of which on the moraine removed it from the main influence of the drainage movement. The strongest winds experienced at this camp were those coming down out of the pocket of the hanging glacier, which lies directly above and behind it; they were presumably a combination of drainage winds and downdraughts from this cirque.

The ice surface, as it appeared in September 1957 when almost two-thirds of the glacier were bare, is composed of elongate hummocks from



Fig. 5. View up glacier from lower camp. Corniced peak is Mount McCall.

0.3 to 2 m. long, which stand up as the high ground between meltwater channels. Most of the glacier, especially the lower half, is covered with a mantle of dust, rock, and boulders, many of which melt into the ice and give it a pock-marked surface. The size and depth of the cavities depend on the objects causing them, and they range from a few millimetres in diameter to basins the size of a bathtub around large boulders. On the lower fourth of the glacier there are several boulder trains the members of which blanket the ice and become pedestalled. As a result of this rough surface travel on the ice is quite easy, except on warm windy or rainy days when melting is rapid and the surface becomes slippery. An area in which the hummocks are much less pronounced lies opposite the lower camp. It is the location of the lower air strip during the months when the snow has melted off the glacier (see Fig. 5).

During the summer of 1957 the summer melt exposed bare ice as far as the area slightly above the confluence of the cirques, and the firn cover on the floors of the cirques was sufficiently sodden and compacted to show the form of the ice in some locations.

The surface runoff from the cirques appears to flow into two main outlets: a marginal stream following the right side of the glacier (facing down flow); and a circular fissure, about 0.6 m. in diameter, probably a former crevasse, which has filled and frozen except for this one well, which is located at the head of the glacier trunk. The depth of this fissure and the immediate destination of the water have not been determined.



Fig. 6. East side of terminus of McCall Glacier, looking up glacier. The gully is filled by a stream in summer.

The stream following the right-hand side of the ice is a major surface feature from the area above the sharp bend to the vicinity of the slight bend below the lower camp where it becomes subsurface until reaching the terminus (see Fig. 6). There is no single drainage feature of this type along the left-hand margin except in the lowest fourth of the glacier and most of the melt water on this side seems to flow over the ice surface. There is a second well into which some surface runoff flows, which is located in mid-glacier a little below the lower camp.

One result of the large loss of snow from melting in 1957 was that a major proportion of the crevasses became visible either through complete denudation of the snow cover or through partial collapse of their snow bridges. Observations showed that there are two principal areas of crevassing other than the ice faces above the cirques and the bergschrunds. The first is located where the ice from the highest cirque flows down to the middle cirque over the end of a rock spine, with a surface slope of over 25 degrees. The second area is another step, also on the left-hand side of the glacier, just below the constriction one-third of the way down the trunk. Both knolls are heavily crevassed from immediately above to half-way down the break in the slope. The largest crevasse explored in these

areas was 5 m. across at the widest point, 60 m. long and an estimated 25 m. deep.

Whereas this appraisal gives only an indication of the amount of crevassing in the cirque bowls, it shows that travel over most of the glacier can be accomplished in relative safety, which is of great advantage in checking the motion profiles.

The majority of the large crevasses in the trunk have widths up to 1 m., they have partially filled with water that later froze, so that their depth is reduced to 2 to 3 m. and the bottom is flat. Still smaller ones, about 0.3 m. or less in width and of unknown depth, tended to fill completely with melt water. Their consequent behaviour has not yet been ascertained.

The crevasses open most noticeably during the winter when they do not fill with water. In the upper half of the glacier more than 24 openings were observed in May that had not been present in October. Two longitudinal crevasses, about 1 m. wide and 18 m. long, were observed near mid-glacier, slightly below the lower camp. The central portions were about 5 m. deep and they were partially filled with melt water, but the drainage was usually sufficient to prevent their being filled completely.

Blue bands are quite frequent in the glacier and are apparently completely random in their orientation. Dirt-filled shear planes are also quite common and in several areas along the right-hand side of the glacier show the effects of lateral shearing in the ice mass. Some offsets amount to as much as 0.6 m. No effort has yet been made to study the stratigraphy or petrofabrics in detail.

From the head to the lower camp the cross section of the glacier is concave upward, but from this area to the terminus the profile is convex. Below the final bend the relief from the marginal stream to the top of the ice shoulder is roughly 20 m.

The data collected at the upper station include continuous records of long and short wave energy gain and loss, air temperatures, and wind speed. They are supplemented by regular visual weather observations and standard U.S. Weather Bureau climatic reports. Snow pits have been dug at regular intervals to a depth of 2.5 m. to study the stratigraphy of the snow and the behaviour of the firn as it begins to turn into ice. Temperatures down to a depth of 100 m. are recorded periodically to follow the changes in temperature gradient in the firn and ice in connection with surface fluctuations of temperature.

Ice motion studies are carried out by triangulation to 80 dowels embedded in transverse and longitudinal profiles. The periodic determination of the positions of the dowels in relation to fixed points gives the motion of the ice during that period and so the average daily motion. This was of the order of 20 mm. per day from June to November 1957.

## NOTES ON THE GEOLOGY OF THE McCALL VALLEY AREA

Charles M. Keeler\*

**T**HE close relationships between diverse types of terrain make the McCall Valley area a particularly interesting one for the ecologist, geologist and geomorphologist. The McCall Glacier, which occupies the upper part of the valley, heads in a region of high serrate granite peaks (2,290 to 2,740 m. above sea-level) and ends in a narrow V-shaped valley that opens into the wider Jago River valley. The tundra, characterized by its vegetation and lack of sharp relief, begins approximately 5 km. from the glacier terminus on the north side of Marie Mountain (see map Fig. 7) at an altitude of 900 m. This rapid transition from icy peaks to vegetated plain within short walking distance is extremely attractive, both scientifically and scenically.

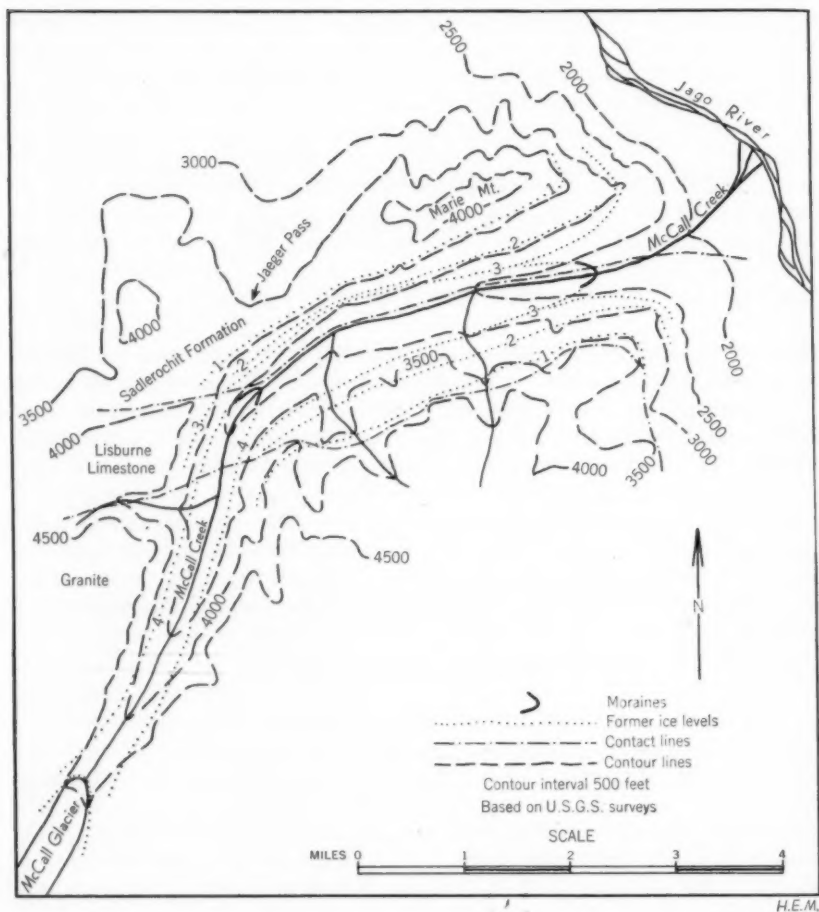
### Previous explorations

It is not known if the McCall Valley had been visited prior to 1957; however, in the early 1900's a prospector, T. H. Arey, travelled along the Jago River from its mouth at the arctic coast to its headwaters, bringing back reports of glaciers existing in its western tributary valleys. E. de K. Leffingwell (1919) travelled extensively in the Canning River region during the years between 1906 and 1914 and described the bedrock and surface geology. One such trip was made along the Okpilak River, which is the first major stream to the west of Jago River. A U.S. Geological Survey party (Wittington and Sable 1948) spent a short time on the Okpilak River in 1948 and did a reconnaissance survey of the bedrock.

### Present work

The writer spent two weeks studying the McCall Valley during the summers of 1957 and 1958. Further observations were made in the course of the regular glaciological work. Mr. E. G. Sable, who was conducting an investigation of the bedrock geology between the Jago and Hulahula rivers during these two summers deserves credit for his many helpful suggestions. Mr. Austin S. Post of the McCall Glacier Project also contributed to this work.

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**Fig. 7.** Map showing McCall Creek from the terminus of McCall Glacier to Jago River and its surroundings. (Note: the names Marie Mountain and Jaeger Pass have not been recognized officially by the Board on Geographic Names and are used here for ease of reference only.)

### The McCall Valley

The area most intensely studied is the part of the McCall Valley between the McCall Glacier and the Jago River. It is roughly 10 km. long and 800 m. across at its widest point. The walls from the glacier terminus to the pronounced easterly bend in the valley (see map Fig. 7) are nearly 450 m. high from valley floor to ridge top and have an average slope of 30 degrees. From the bend to the valley mouth the walls are less steep and

covered with a sparse moss and grass vegetation, in contrast to the bare talus slopes farther up stream. It is in this lower vegetated area that traces of past glacier fluctuations are best preserved. The valley floor is covered with stream-carried debris of boulder size and patches of clay and silt (glacier flour). The stream occupying the valley floor is as much as 30 m. wide, but generally braided so that no channel is more than 6 or 9 m. wide. The average stream gradient is 4 degrees. As the water is mainly derived from melting of the McCall and other glaciers the stream volume is regulated by the same factors that affect glacier ablation. For example, the water level was noticeably higher during thaws than during cold periods. Both the McCall Creek and its tributaries have built up alluvial fans where they debouch to compensate for glacial deepening of the master stream valleys. The fan of the McCall Creek is nearly 1.6 km. wide along the Jago River and has a gradient of 4 degrees. The creek bed is well incised in the fan. This reflects a change from aggrading to degrading conditions, which is the result of an increased volume of water due to the present high rates of glacier ablation.

### Bedrock

The bedrock in the area consists of a sequence of north-dipping sediments abutting against a granite mass of an estimated areal extent of 650 sq. km. The contact between sediments and granite in the McCall Valley area is believed to be a normal fault with upward movement on the southern or granite side.

### *Lisburne Limestone*

This formation was first described by Collier at Cape Lisburne on the northwest coast of Alaska; it is continuous along the Brooks Range. It crops out approximately 3.2 km. below the terminus of the McCall Glacier, where it crosses the creek as a belt 400 to 1200 m. wide, trending east-west along the ridge west of the creek and continuing for 6.4 km. down the creek valley. The predominant rock type is a dark-grey, fine-grained, massive limestone, which weathers light-grey to buff. The section in this area is believed to be 240 to 300 m. thick and probably corresponds to the Alapah member of the Lisburne Limestone that is found in the central part of the Brooks Range. Its age is generally agreed to be Upper Mississippian.

### *Sadlerochit Formation*

The Sadlerochit Formation was originally named by Leffingwell (1919) and the type section is found on the south slope of the Sadlerochit Mountains. The contact between it and the Lisburne Limestone is buried under alluvial deposits in the McCall Valley; however, it overlies conformably the Lisburne Limestone on the Okpilak River (Wittington and Sable 1948).

The formation crops out on the south slope of Marie Mountain and Jaeger Pass in a belt 800 m. wide. There it consists of slaty shales and siltstones, brownish in colour and greatly contorted; it is Permian in age.

### Granite

The granite of the area is part of a small batholithic mass with an estimated extent of 650 sq. km., which lies between the Jago and Hulahula rivers. In the McCall area its predominant composition is quartz, microcline feldspar, and biotite, with small traces of muscovite, galena, and molybdenite. Both pegmatic and aplite dykes are found.

About half-way up the glacier there is a shear zone, roughly 2.6 sq. km. in extent, which has undergone hydrothermal sulfide enrichment. No sulfides were crystallized to a sufficient extent to permit field identification. In the upper cirque of the McCall Glacier there are three mafic dykes, which strike northeast and dip south. They are extremely fine-grained and contain inclusions of coarse-grained granite along their borders.

As the nature of the contact between the granite and the country rock is not fully determined it is difficult to give an age for the granite. E. G. Sable (personal communication) reports that along the Jago River there are blocks of Kayak quartzite (Lower Mississippian), which have undergone metamorphism due to emplacement of the granite, hence the granite cannot be pre-Mississippian.

Both sediments and granite are much sheared and there is a strong cleavage trending northeast. The sediments north of the granite are locally folded and overturned.

### Glacial geology

Evidence of multiple glaciation in the McCall Creek valley is fairly abundant despite the wide-spread destruction of surface features by talus slides and solifluction. Past advances of the McCall Glacier are marked by lateral and end moraines in the lower part of the valley and by trimlines and truncated spurs in the upper part. The relationship of these features to the moraines of the Jago River valley is best expressed in terms of similar elevations above the valley floors.

Extensive erratic-free areas at high altitudes strongly suggest that glaciation was of the alpine-valley type. Investigators in the central Brooks Range have also remarked on the lack of a regional ice cap (Detterman *et al.* 1958).

The highest glacial features in the lower valley are found at an altitude of 390 m. above the present valley floor. The highest evidence of glaciation in the upper valley is 300 m. above the present glacier. For ease of reference the various stages of glaciation will be referred to by numbers in order of decreasing age (see Figs. 8 to 10).

*First advance.* The first glaciation in the McCall Valley reached and joined the Jago River valley glacier. The most distinctive feature connected with this glaciation is a plane surface on the south side of McCall Creek opposite Marie Mountain. This surface slopes downstream with a gradient of 5 degrees and is continuous from the bend in the creek to the Jago River valley, except where it has been dissected by north-flowing tributary streams. It lies between an altitude of 225 and 390 m. above the stream and is slightly tilted toward the centre of the valley. Its upper altitude is concordant with that of Jaeger Pass and the top of the Jago River lateral moraines. It has no surface relief and is covered with boulders, predominantly of granite, and thin tundra vegetation. The bench is being encroached on by talus slides from the slopes above it. This is probably not a glacially carved feature as neither ice nor a marginal stream would cut laterally into bedrock on a level with the top of a glacier. A more likely explanation is that this is a raised erosion surface similar to those seen along the west side of Hulahula River valley. The bench is important in terms of glacial geology in that erratics and other glacial features are not found above it, so that it makes a very distinct marker of the upper limits of glaciation.

Erratics are not found on Marie Mountain above an altitude of 1,100 m. indicating that, whereas ice did cross Jaeger Pass, it was not much more than 60 m. thick. As erratics are also found on the north side of Marie Mountain at the same altitude it would appear that Marie Mountain stood as a nunatak above the ice that flowed around it from Jaeger Pass and the Jago River valley.

In the upper valley the highest signs of glaciation are truncated spurs whose summits stand at 275 to 300 m. above the present glacier surface. All features of this stage are well covered with tundra. Individual boulders are lichen-covered and have weathering rinds 1.25 cm. thick.

*Second advance.* The second distinct glaciation in the McCall creek area reached the Jago River valley where it joined with the Jago Glacier. This glaciation left trimlines in the upper valley and lateral moraines below the present glacier. The trimlines stand 225 m. above the present glacier and are marked by outcrops above and talus slopes below, indicating an attempt to compensate for glacial steepening of the lower slopes.

Little is left of the lateral moraines due to extensive mass-wasting. A fairly prominent patch of moraine is found on the ridge of Marie Mountain where the McCall Valley joins the Jago River valley, but farther upstream the only remains are noticeable concentrations of granite boulders at an altitude of 275 m. above the valley floor. The moraines are thinly covered with tundra and all boulders are lichen-coated.

*Third advance.* The third glaciation also reached the Jago River valley, but was only 150 m. thick in the lower McCall Valley. End moraines near the mountain front in the Jago Lake area suggest that the ice in the Jago



Fig. 8. Looking east toward Jago River from Jaeger Pass. Note: (1) slight bench of first advance, (2) lateral moraines of second advance, (3) lateral moraine and end moraines (near Jago River) of third advance.

River valley was not much thicker and did not extend as far as the coastal plain.

This advance is represented in the McCall Valley by lateral moraines (see Fig. 8) and a recessional moraine found 1.6 km. upstream from the confluence of the McCall Creek and the Jago River. The moraine is a mound, steeply banked up stream, more gently so down stream, which swings out from the north side of the valley. It is composed of boulders 15 to 30 cm. in diameter and is thinly covered with a mat of tundra. Up stream from this moraine are found lateral moraines of a similar appearance. Individual boulders of this stage are lichen-covered, but are not much weathered.

*Fourth advance.* The fourth and last glaciation of major significance in the McCall Valley reached the bend in the valley where it left an end moraine (see Fig. 9), which has since been greatly dissected by the creek. The moraine stands 75 m. above the stream and is composed of very loosely packed boulders 15 to 22 cm. in diameter. Up stream from it are lateral moraines of similar composition. Down stream there is an extensive but thin drift cover, which has been terraced by the creek leaving two sets of paired terraces. The upper and older terrace is covered with small willows and underwent dissection during the period following the fourth glaciation.



Fig. 9. Looking south toward McCall Glacier from Jaeger Pass. Note: (1) truncate spur of first advance, (2) trimlines of second advance, (3) trimlines of third advance, and (4) end moraine of fourth advance.

**Fifth advance.** The most recent glaciation was very slight and its deposits are hard to differentiate from those now being formed along the present glacier. They consist of unweathered material found as end and lateral moraines, which stand 15 to 23 m. above the present ice level. From the McCall Glacier terminus these moraines extend down valley for 180 m. (see Fig. 10). A small glacier, whose terminus is less than 90 m. from the McCall Glacier, is completely blocked off by lateral moraines of this stage, indicating how small this advance must have been. Drift from this glaciation has been carried down stream and is currently being terraced. In the upper part of the valley the lateral moraines are replaced by trimlines; above them the bedrock is lichen-covered and below them it is bare.

#### Correlation of glacial sequence

Correlation of the glacial sequence of the McCall Valley area with that of the central Brooks Range (Detterman *et al.* 1958) can be made on the basis of the morphology of the deposits and their geographical distribution. The oldest glaciation is comparable to either the Anaktuvuk or Sagavanirktok glaciation of the central Brooks Range in that it had a piedmont phase and the deposits are well covered with tundra. The second glaciation is comparable to the Itkillik glaciation farther west as it was

the last advance to pass beyond the mountain front. Deposits of the third advance are very similar in character to those of the Echooka glaciation. The deposits of the fourth advance occupy a geographical position similar to those of the Alapah Mountain glaciation and the fact that they are tundra-covered supports this correlation. The fifth glaciation appears to be entirely similar in its geography and physical expression to the Fan Mountain glaciation.

No material suitable for carbon-14 dating was found, as was to be expected in a narrow arctic valley. A lichenologist would probably be able to date the moraines of the region more accurately.

### Geomorphology

The large grain size and porous nature of the unconsolidated sediments in the McCall Valley is unfavourable for the extensive development of patterned ground; however, some features of this are not entirely lacking. Poorly sorted, high-centred polygons with an average diameter of 1.5 m. were observed on the high bench above McCall Creek. Similar polygons were seen on the top of the recessional moraine of the third advance. Small stone steps (non-sorted steps, Washburn 1956) occur on the slope leading from the high bench to the mountain-side above. These steps have



Fig. 10. Terminus of McCall Glacier. The light-coloured rocks are unweathered deposits of fifth advance.

an arcuate ground plan, with risers 15 cm. high and treads from 30 to 90 cm. wide. Stone circles 1.5 to 7.5 m. in diameter are arranged in rows on the McCall Creek fan; the rows are separated by marshy areas.

Small solifluction lobes are fairly common on the north side of the valley on slopes that have gradients of 15 to 20 degrees. A typical lobe has a 15-metre wide arcuate (in plan) scarp, which is 60 cm. high and well vegetated. The lobe is roughly wedge-shaped with a great concentration of boulders in troughs along the sides. A few boulders are scattered on its upper surface and some of the flatter ones were seen to be standing on end. The presence of willows on the scarp suggests that at present movement is slight or non-existent.



Fig. 11. Terminus of McCall Glacier with aufeis field in foreground. Note large boulders on glacier surface, and track in right foreground for scale.

### Aufeis

A rather extensive aufeis field has developed below the terminus of the McCall Glacier (see Figs. 11 and 12) and extends for 400 m. down stream to where McCall Creek enters a narrow gorge. The ice in the field is nearly 6 m. thick in places and shows an alternation of large-grained white ice and dense blue ice resulting from refreezing of pure melt water and recrystallization in the snow cover due to alternate freezing and thawing.



Fig. 12. Looking down stream from the terminus of McCall Glacier. Note lateral moraines and aufeis field.

At the beginning of summer, surface streams flow over the field in an anastomosing pattern until one channel cuts through the ice to the underlying gravels, after which the pattern becomes dendritic. The main channel is enlarged by block stopping as the master stream undercuts its banks.

In April 1958 there were no traces of any channels remaining and the field had become perfectly healed, suggesting that a great quantity of water had frozen. At this time running water was issuing through cones on the surface of the field. It is this water that apparently regenerates the field after the summer melt. The fact that the water was rising vertically indicates that it is backed by considerable pressure.

It is hard to conceive of a likely source of the water, since April is well in advance of the ablation season. The heavily fractured granite could act as reservoir for the ground water. However, it is to be expected that it would be frozen during the winter unless there is a source of heat in the granite fairly near the surface. Another possibility, which is more likely, is that sub-glacial streams are becoming dammed up in early fall by surface freezing at the glacier terminus. Their volume gradually builds up until the pressure increases sufficiently for the water to burst through or under the dam and flow through the terminal outwash and rise some-

where in the ice field. This mechanism is similar to that cited by Leffingwell (1919) as the process acting in river icing.

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## SIR WILLIAM EDWARD PARRY\*

R. N. Rudmose Brown

SIR William Edward Parry (1790-1855), British admiral and arctic explorer, was born at Bath on December 19, 1790, the son of Caleb H. Parry, a physician of some celebrity of Devonshire descent. Educated at Bath Grammar School, he was a forward child, quick to learn, with an ear for music, and tall and athletic. His parents intended that he should study medicine; his going to sea was largely due to the chance that a friend of the family was Admiral W. Cornwallis. In June 1803 the Admiral agreed to take the boy on board his flagship *Ville de Paris* as a volunteer. War with France in those days made the Navy keen on recruits of any age. Parry had never seen the sea before the day of joining and had no strong leanings toward a naval career, but he soon made good and won the esteem of his officers. His ship was engaged in patrolling the Channel in the blockade of French ports, especially Boulogne, from which was expected Napoleon's invasion of England. Only on one occasion, however, was there a brush with the enemy.

Early in 1806 Parry was appointed a midshipman in the frigate *Tribune*, which also patrolled the French coast. In 1808 he was transferred to the *Vanguard* in the Baltic fleet and, in charge of a gunboat attached to the *Vanguard*, he had several brushes with Danish gunboats. The *Vanguard* returned late in 1809 and Parry passed his examination for lieutenant in 1810 and joined the frigate *Alexandria* on convoy duty for the Baltic. There were several engagements with Danish schooners and gunboats but nothing very serious. For some time Parry's ship lay off Karlskrona, Sweden, "in case we should be inclined to Copenhagen them." In 1811 the *Alexandria* was on the Leith station and Parry spent the winter of 1811-12 at Cromarty, Moray Firth, Scotland, where he became much interested in the construction of the Caledonian Canal. On patrol in protection of whales, his captain had orders to go as far north as latitude 76°N. but was baffled by pack ice around Bear Island and failed to reach Spitsbergen. Parry's interest in navigation led to his publishing in 1813 "Nautical Astronomy by Night", which gained wide use in the Navy. Next he served in *La Hogue* on the Halifax (North American) station, crossing the Atlantic in the *Sceptre*. There were a few exciting incidents, for Britain was then at war

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with the United States and Parry saw the *Shannon* with her prize, the *Chesapeake*, enter Halifax harbor. When *La Hogue* in 1814 returned to England, Parry, determined to remain on the North American station, transferred to one ship after another until early in 1817, when the serious illness of his father brought him home. Parry then contemplated a project for exploring Central Africa but this came to nothing.

The end of the Napoleonic wars and the setting free of many sailors and adventurous spirits led in 1818 to a minor boom in arctic voyages, with the problem of the Northwest Passage in the forefront. There was no more powerful advocate than Sir John Barrow, secretary to the Admiralty and one of the founders of the Royal Geographical Society. His arctic interests seem to have dated from youth, when he made a summer voyage in a Greenland whaler — a not uncommon beginning for polar travelers in years to come. Barrow held that of the various passages between Atlantic and Pacific that might exist "the northeast holds out the least encouraging hope" but that there was much hope of the discovery of the shorter Northwest Passage and also of a polar one. "That the North Pole may be approached by sea has been an opinion entertained both by experienced navigators and by men eminent for their learning and science." From time to time a whaler would report exceeding the parallel of  $80^{\circ}\text{N}$ . between Greenland and Spitsbergen and, allowing for roughness of observation, there seemed hope of navigable waters to high latitudes, perhaps to the Pole, in favorable years. A Northwest Passage, however, did not exist south of the Arctic Circle. The probable insularity of Greenland made possible an east-west passage, most likely in high latitudes, but Barrow adds that "although a communication may, and in all probability does exist between the two oceans, it by no means follows that there must also be found a navigable passage for large vessels." Several whalers in recent years had claimed to have reached high latitudes east of Greenland. A Hamburg ship in 1817 had traced the coast of Greenland as far north as latitude  $70^{\circ}$ . In the same year two English whalers claimed to have sailed beyond latitude  $72^{\circ}$  and  $75^{\circ}\text{N}$ . respectively. On the other hand, Baffin's discoveries in 1616 of Baffin Bay and openings to the north and west were discredited by many sailors. Barrow said of the voyage, "It is most vague, indefinite and unsatisfactory and the account is most unlike the writing of William Baffin."

Lastly, the occurrence of good ice conditions north and west of Spitsbergen in 1816 and 1817 was held, probably quite erroneously, to herald even more open conditions in 1818. Under these circumstances the advocacy of Sir John Barrow was successful in ordering the dispatch of two polar expeditions in 1818. One, consisting of H.M.S. *Dorothea*, Captain D. Buchan, and H.M.S. *Trent*, Lieutenant J. Franklin, was to try the polar route. It sailed north of Spitsbergen but accomplished little. The other was composed of H.M.S. *Isabella*, 385 tons, Captain J. Ross, and the hired brig, *Alexander*, 252 tons, Lieutenant W. E. Parry. The *Isabella* carried 57 officers and men, and the *Alexander* 37. Both, which were of course wooden vessels, were strengthened for their task. Parry notes that his vessel was much slower

and less wieldy than that of Ross, and so he had difficulties in keeping up with the *Isabella*.

They left the Thames on April 18, 1818, and, calling at Lerwick, Shetlands, rounded Cape Farewell on May 27. On June 17, their progress was stopped by pack ice in the neighborhood of Hare Island in about latitude  $70^{\circ}\text{N}$ . The position of this island was accurately determined. Here Ross and Parry joined an ice-bound fleet of over 40 whalers and were forced to stay until June 20. Following the advice of the whalers, Ross hugged the Greenland shore as he struggled north, battling with gales and heavy pack ice. His ships suffered minor damage but gradually gained northing. The strength of the ships saved them when jammed among heavy floes but they had the usual difficulties to face in crossing Melville Bay; the narrowest escape from being crushed was on August 8 when the ships were beset by heavy ice. If the floes had not receded the ships might have been lost.

On the same day land was seen in latitude  $75^{\circ}54'\text{N}$ . and near Cape York a small number of Eskimo with dog sledges were met. Ross had great difficulty in allaying the fears of these natives who never before had seen a ship or white men. They had hunting knives of meteoric iron which was said to be found near Cape York. This small group of Eskimo has a culture that depends on ice hunting throughout the year, using the vast ice fields of Inglefield Gulf and Wolstenholme Bay. They have abandoned the technique of summer hunting with kayak and umiak, and of caribou stalking and salmon fishing. Ross called these people Arctic Highlanders. Now they are called Polar Eskimo. North of Cape York so-called "red" or "pink" snow was observed on the cliffs which Ross named Crimson Cliffs. This phenomenon had been recorded by arctic travelers over a long period of time in various localities but it was only subsequent to this voyage that the cause was determined to be the presence in the melting snows of early summer of countless microscopic algae.

Ross pressed on impatiently, passing without examination the mouths of Wolstenholme and Whale sounds. His farthest north was latitude  $76^{\circ}54'\text{N}$ . The entrance of Smith Sound was blocked by ice but neither it nor Jones Sound was adequately examined and Ross seems to have assumed that neither was a through channel. Then Baffin's Lancaster Sound was reached with an entrance clear of ice and a depth of 660 to 1,000 fathoms. The ships stood in, everyone on the alert, expectantly looking for the long-sought passage. Parry especially had great hopes, though Ross said that the "general opinion was that it was only an inlet." After running westward for 30 miles, or as Ross says 80 miles, he (Ross) states that on August 31 he saw a chain of mountains (Crocker Mountains) ahead of the ships extending from north to south, and also a continuity of ice. Ross therefore ordered the ships to turn about, and leave the sound. Parry could not understand this decision but of course had to obey, even though he saw no land or ice barrier ahead. From Lancaster Sound the ships turned southward and on October 1 arrived off Cumberland Sound, but Ross did not examine it though it certainly suggested a way to the west. He arrived home the same month.

Ross had confirmed the old discoveries of Baffin but his contribution to the problem of the Northwest Passage was small. It was therefore not surprising that the next expedition was put in charge of Parry instead of Ross, and the route of advance was again to be by Baffin Bay and Lancaster Sound. The two ships were H.M.S. *Hecla*, 375 tons, with 58 officers and men, and H.M.S. *Griper*, 180 tons, with 36 officers and men. Parry was in command of the *Hecla* and Lt. Liddon was in command of the *Griper*. The *Hecla* as a rule had to be kept under easy sail to allow the *Griper* to keep up with her, for the *Griper* was a poor sailor. Captain E. Sabine was in charge of the scientific work, and among the other officers were Lieutenants F. W. Beechey and H. P. Hoppner.

The ships, provisioned for two years, left the Thames on May 8, 1819, and met the pack in the middle of Davis Strait on June 18. Sailing through much pack ice, they won a way northward and arrived off the entrance to Lancaster Sound on July 30, a month earlier than Ross had done the previous year. Parry wrote: "We were now about to enter and to explore that great sound or inlet which has obtained a degree of celebrity beyond what it might otherwise have been considered to possess, from the very opposite opinions which have been held with regard to it." This was the decisive turn in the voyage. Either the sound was a blind alley or it led to channels by which the Pacific might be reached. Several whales, including a number of young ones, were sighted, a discovery that led to extensive whaling in Lancaster Sound in years to come. On August 2 "more than forty black whales were seen during the day." A sounding in the entrance of the sound gave 1,050 fathoms with a bottom of mud and small stones but owing to the ship's drift Parry doubted if the real depth was more than 800 to 900 fathoms. Anticipating that the *Hecla* might be delayed by the slower *Griper*, he arranged a rendezvous at the meridian of 85°W. in the middle of the sound, but a strong easterly breeze helped the *Griper* along. On August 3 they were between Capes Warrender and Osborn, the two capes on the northern side of the entrance on Devon Island, or North Devon as named by Parry. The dark-looking hill just north of Cape Osborn, called Hope Monument and thought by Ross, who named it, to be an island was found to be on Devon Island. A solitary iceberg was visited by Sabine, Beechey, and Hooper for observations on variations. A sounding gave 373 fathoms, and a current reading gave a speed of 0.88 mi. per hour N. 65°E.

Parry wrote of the hope and excitement on board as the vessels sped westward before a strong breeze. "It is more easy to imagine than to describe the almost breathless anxiety which was now visible in every countenance while, as the breeze increased to a fresh gale, we ran quickly up the sound. The mastheads were crowded by officers and men during the whole afternoon." An inlet to the south was noted and called Navy Board Inlet. "We saw points of land apparently all round this inlet . . . at a very great distance but our business lay to the westward, however, and not to the south." Meantime, land appeared on the northern side of the sound westward of Cape Warrender, "consisting of high mountain, and in some

parts of tableland." A large opening on the north was named Croker's Bay, "though the quickness with which we sailed past it did not allow us to determine the absolute continuity of land round the bottom of it." He believed, however, that it might be a passage from Lancaster Sound "into the northern sea."

With a fresh breeze the *Hecla* raced ahead and by midnight on August 3 had reached longitude  $83^{\circ}12'W$ . with the shores of the channel "still above 13 leagues apart." Ross's continuity of land, sometimes called the Croker Mountains, had almost certainly been disproved. Depth was now 150 fathoms. There were still many whales. The *Hecla* waited for the *Griper* and the two ships went on to the westward. Reefs were seen to the north off Cape Bullen. In a rough sea the *Griper* sounded in 75 fathoms but as apparently stranded floes inshore suggested shoal water, Parry marked the region on his chart to warn future navigators. At noon on August 4, in longitude  $86^{\circ}30'30''W$ ., two inlets in the coast of Devon were sighted, Burnett and Stratton inlets; the depth was 170 fathoms. Parry noted the horizontal stratigraphy of those lands and the "buttresses" of the cliffs, which are probably slopes of scree. The sea was free from pack ice off Fellfoot Point, the water was "the usual oceanic colour, and a long swell was rolling in from south and east. Some of the most sanguine among us had even calculated the bearing and distance of Ice Cape, Alaska, as a matter of no very difficult or improbable accomplishment."

By the evening of August 4 Parry's good luck began to fail. From north to south across the sound heavy pack ice extended from Maxwell Bay on Devon Island to Leopold Island and Somerset Island, and a strong "ice blink to the westward afforded little hope." Here Parry noted many white whales and birds. Several schools of narwhals were also seen. On August 5 the ships reached longitude  $39^{\circ}18'40''W$ . in a depth of 135 fathoms with an eastward-setting current of 9 miles a day. The pack offered no passage. Some time was devoted to bringing ice on board for water supply and Parry comments on the better value of berg ice and the necessity of letting floe ice drain if it is to be used.

The ships stood south on August 5 with the intention of seeking, in a lower latitude, a clearer passage to the westward "than that which we had just been obliged to abandon." The compass became more sluggish and irregular as they moved southward in Prince Regent Inlet. After about 100 miles on this southward course, in latitude  $71^{\circ}53'30''N$ ., Parry returned to Lancaster Sound as a more promising route. His extreme southern landfall was Cape Kater. From August 13 to 18 he tried and failed to make westward on the southern side of the sound. Then he crossed to the northern side, which subsequent exploration has shown to be a wise plan.

On August 21 there was clear water before them; all the ice had moved away. A breeze enabled them to move westward examining from boats the coast of Devon Island. At length the coast began to trend northward with open water and distant land. Parry decided this wide stretch of water was

a channel and he named it Wellington Channel. But he held westward into Barrow Strait, along which he made slow progress. A band of pack appeared across the strait but the ships were forced through it. More ice appeared but was passed. New islands were sighted. Land to the north was named Cornwallis and Bathurst and other islands received names. Fog, light winds, and streams of pack impeded progress but by September 4 the ships had reached the meridian of  $110^{\circ}\text{W.}$ , an attainment which earned for them the sum of £5,000 offered by the British Government to such British subjects as might reach so far westward within the Arctic Circle. A headland on Melville Island in longitude  $109^{\circ}50'\text{W.}$ , was suitably named Cape Bounty.

In spite of somewhat unpromising conditions, Parry had not lost hope of gaining the Pacific. He believed that experience had shown September to be an open month for arctic navigation: "I determined to extend our operations to the latest possible period." On September 8 they were abreast of Cape Providence, toward the western end of Melville Sound. A week later, in longitude  $112^{\circ}29'30''\text{W.}$ , they were held up by ice and heavy winds. "I was reduced to the disagreeable necessity of running back to the eastward of Cape Providence." On September 20 Parry decided that the time had come to look for winter quarters and he chose a bay, on the southeastern coast of Melville Island, which he called Winter Harbor. Here he cut a canal of over 2 miles through a 7-inch floe by which the ships reached an anchorage of 5 fathoms on September 6.

Preparations for facing an arctic winter, an ordeal of grim severity in those days, were at once put in hand. The decks were roofed over, stores collected ashore, regulations made regarding rations, and, most important of all, hunting parties were kept regularly at work. It is stated that during the winter 3,766 pounds of caribou, musk-ox, etc., were killed. This fresh meat and the stock of dried vegetables, and the less important lime juice and freshly grown mustard and cress kept scurvy in abeyance. There were mild attacks but no deaths. The only fatality among the 94 people on the two ships was due to pulmonary trouble. Frostbite, too, was at a low level of occurrence. Indoor amusements included a weekly journal, the usual device of old-time polar expeditions for which the modern expedition with its winter work has no time. There were also theatricals and an elaborate masquerade and, of course, a Christmas feast. And there were classes to teach reading and writing.

No exploration was done until April when a 4-weeks' tour — the first on record from a wintering ship — was made across Melville Island to Hecla and Griper Bay and to Liddon Gulf and back; a team of men dragging a wheeled cart, loaded with fuel and provisions, with incredible exertion over snow and rocks and through slush and rivers.

The ice in the landlocked bay of Winter Harbour was slow to break up, but as the snow melted much of the low ground was revealed as being covered with vegetation, and game was plentiful. On August 1, 1820, the ships were released with the help of a channel sawn in the floe. Turning

westward, Parry was soon held up by heavy pack and gave up the attempt in longitude  $113^{\circ}48'29''$ W. after sighting from Cape Hay, Melville Island, high land in the distance. This was Banks Island between Parker Point and Rodd Head. Efforts to find a way to the west through the pack around Cape Dundas failed and the *Griper* had a narrow escape. "It became evident from the combined experience of this and the preceding year that there was something peculiar about the southwest extremity of Melville Island which made the icy sea there extremely unfavorable to navigation." The ice to the west and southwest of Cape Dundas was "as solid and compact, to all appearance, as so much land." Parry was unprepared for another winter and decided to return to England. On the way he discovered Somerset Island (North Somerset). In 6 days the ships reached Baffin Bay and by the end of October were home.

Parry met with justified acclaim. He had so nearly found a passage to the west that there could be no reasonable doubt of its existence. On the arrival of the ships in the Thames a thanksgiving service was held in the church of St. Mary-le-Strand. His native city, Bath, conferred on him its freedom; Norwich followed suit. He was also elected a Fellow of the Royal Society. The British Admiralty, keen to pursue further the quest, began at once to prepare a team for a new expedition. The ships were H.M.S. *Fury*, 377 tons, under Commander Parry, and H.M.S. *Hecla*, 375 tons, under Commander G. F. Lyon. F. R. M. Crozier, J. C. Ross, and H. P. Hoppner were among the lieutenants. The total of officers and crew was 118. The *Fury* and the *Hecla* were twin ships with interchangeable fittings, a precaution that Parry had suggested.

Parry believed that a more favorable passage might be found farther south. The official instructions were to sail westward through Hudson Strait, reach the mainland coast of North America and follow it northward to Bering Strait and the Pacific. This course depended upon the belief held by many authorities that Middleton's Repulse Bay was a through passage. The ships left the Nore on May 8, 1821, accompanied across the Atlantic only by a store ship.

On July 2 they came in sight of Resolution Island, at the eastern entrance to Hudson Strait, where they met difficulties and dangers due to strong currents and large icebergs and the *Hecla* sustained some damage. Early in August they reached Southampton Island and then a decision had to be made. Should they go north or south? North by Frozen Strait, if it afforded a passage, would take them quickly to Repulse Bay; south by a longer route would lead also to Repulse Bay by Roes Welcome Sound. Parry chose Frozen Strait and made the passage in spite of one belt of pack ice. At the north end of Southampton Island a great bay was named for the Duke of York. A landing was made on the western side. From this bay the ships moved northward through rock-strewn shoals and some ice into Repulse Bay. This was clear of ice and a thorough search failed to find the hoped-for passage to the west. Fairly luxuriant vegetation, much game,

and ruins of Eskimo settlements were found. Parry then returned to Frozen Strait, seeking a northward route.

After some difficult navigation among the islands and rocks of the western side of Foxe Channel and a close examination of every inlet of the southern end of Melville Peninsula, the ships were back again on September 2 to where they had been a month before and no progress in the discovery of a way to the west had been made. Every route seemed to be closed by land. The bad weather, together with strong currents, reefs, and worsening ice conditions, caused the near wreck of the *Fury*, and Parry realized that winter quarters had to be found. An inlet, more promising in its course than others, once more disappointed them. It was named after Lyon, and near its mouth an anchorage was found at Winter Island in  $66^{\circ}32'N.$ ,  $84^{\circ}W.$  It provided little shelter from the south, but proved satisfactory. Here the ships lay from October 8, 1821 to July 2, 1822.

The winter was passed in comparative comfort, which in large measure was due to the visits of tribes of Eskimo, who not merely hunted for the explorers but taught them some of the necessary technique. Thus there was no serious outbreak of scurvy. One of the Eskimo, a woman named Kigliuck, was found to have more than ordinary intelligence and a considerable knowledge of the distribution of land and water in that area. She was persuaded to draw a plan, which lacked a sense of scale but had some sense of direction. It showed the coast extending northward of Winter Island and then turning east, then west, and then south-south-west to within three or four days' journey of Repulse Bay. This suggested a strait to the west and all hands had high hopes when on July 2, 1822, the ships put to sea, after the ice had broken up along a canal that had been started in early June.

Ice, carried southward by a strong current, impeded progress but by July 12 the ships were off the mouth of Barrow River in latitude  $67^{\circ}18'N.$  and soon reached the fertile peninsula of Amitioke. Signs of Eskimo became more abundant. High land to the north proved to be at the entrance to an inlet or strait, but it was frozen over and quite unnavigable in the middle of July. Four weeks of struggle got the ships no farther than the entrance. Parry therefore decided to make a land journey and, setting out on August 14, in a few days reached an east-and-west strait, two miles wide with an eastward-setting current of at least two knots. It was named Fury and Hecla Strait and thought to be the long-desired passage. Ice barred any attempt to sail along it. A land party under Lieutenant Reid went 60 miles to westward on the northern shore to latitude  $70^{\circ}N.$  and thence they saw the southern shore trending southward. This strait is actually about 100 miles in length and is probably rarely navigable.

It had now become necessary to look for suitable winter quarters. Igloodlik, an island to the south of the eastern entrance and much frequented by Eskimo, was chosen, and again Parry indulged in canal cutting, this time for a length of 4,343 feet. Once more Eskimo hunters helped the men through the winter. On August 8, 1823, after cutting through a mile of ice,

the ships were again free, but the ships' surgeon found the men too enfeebled with symptoms of scurvy to risk another season in the North. Parry had planned to send home the *Hecla* and keep the *Fury* for two years more if necessary and so solve once and for all the problem of the passage. He took his surgeon's advice, however, and sailed for home. The two ships reached Lerwick, Shetland Islands, on October 10, 1823, and were in the Thames on October 21.

It had been a most important expedition. Though it had not been successful in finding the Northwest Passage, at least it had added much to the knowledge regarding Arctic America and possible routes to the west. Parry's reputation stood high and the following year, 1824, he was put in charge of another naval expedition, again with the *Hecla* and *Fury*. He had among his officers several old associates and future explorers, H. P. Hoppner, J. C. Ross, H. T. Austin, H. Foster, F. R. M. Crozier, and C. Richards. The total strength was 122, all told. In the same year G. F. Lyon, in the *Griper*, made an independent and unprofitable voyage to Repulse Bay and J. Franklin a land journey.

Parry sailed on May 19, 1824, with orders to explore the southern end of Prince Regent Inlet in the hope of finding a passage. "I saw no reason," said Parry, "to doubt the practicability of ships penetrating much farther to the south by watching the occasional openings in the ice. It is also probable that a channel exists between North Somerset and the northern coast of America." Ice conditions in Baffin Bay proved very bad and it was not until September 10 that the ships reached Lancaster Sound. New ice was rapidly forming and winter had begun when winter quarters were established at Port Bowen, on the eastern side of Prince Regent Inlet, in latitude 73°14'N. after Parry's usual cutting of a canal. This northwestern part of Baffin Island proved to be a barren and desolate region. A few bears were shot but hares were scarce and there were no caribou. In the immediate vicinity Eskimo remains were scanty.

In June 1825, J. C. Ross made a land journey to the north of Cape York, the northwestern extremity of Baffin Island, and saw Barrow Strait clear of ice. H. P. Hoppner made an eastern journey over entirely barren and rugged land but established little. J. Sherer made a journey south to Cape Kaye, latitude 72°15'N., and found many Eskimo remains. On July 20 the ships left Port Bowen and stood across the inlet to the west. They met heavy ice and severe gales. The *Fury* went ashore several times and was so badly damaged that she had to be abandoned, all hands being transferred to the *Hecla*. The *Hecla* then refitted in Port Neill, a small harbor a little south of and much superior to Port Bowen. She left this anchorage on August 31 and reached Sheerness on October 20, 1825.

The expedition had been most disappointing and had added little or nothing to the solution of the problem of the Passage. Already in 1823 Parry had been made acting hydrographer; on his return he was made hydrographer. He did not try again to find the Northwest Passage. His arctic days, however, were not over. On the contrary, he virtually initiated the

attempts to solve the second great problem of arctic exploration, the attempt to reach the Pole. No arctic explorer had wider experience than Parry when his plan was accepted by the Admiralty and the Royal Society in 1827. His ship was again the *Hecla* and he had with him among others, J. C. Ross, H. Foster, F. R. M. Crozier, and R. McCormick. The project, which had the support of W. Scoresby and J. Franklin, entailed travelling over the pack or through open water from a high northern land base. Spitsbergen, as lying within 600 miles of the Pole and being relatively easy of access, was chosen as the base; supplies for 90 days were to be taken, thus providing for an average speed to and from the Pole of 13.5 miles per day. Parry was ordered also to survey the northern and eastern coasts of Spitsbergen and to make magnetic, meteorological, and hydrographic observations and to collect specimens of plants, animals, and minerals, and to report on the whaling industry and its future.

The *Hecla* left the Thames, towed out by a steamer, on March 4, 1827. On the way across the North Sea, Parry tested sledge equipment and clothing and experimented on his polar party with a diet of pemmican. At Hammerfest he embarked eight reindeer as draught animals. They were never used. On April 29 the ship left for the north and soon fell in with several whalers. On May 11, Black Point (Salpynten), at the southern end of Prince Charles Foreland, was sighted and on May 14 Hakluys Headland. Here the ship was caught in drifting pack and incurred some risk from pressure. It passed Cloven Cliff (Klovningen) and Red Bay (Raudfjorden). A reserve supply of provisions was landed on Red Beach as a precaution against the loss of the ship. Then it drifted past Wide Bay (Wijdefjorden) and from a boat Parry examined Mussel Bay (Mosselbukta) and found it unsuitable for a harbor. Forty-five years later Nordenskiöld was to find it most satisfactory. At Verlegen Hook (Verlegenuken) the ship got clear of the ice. On June 14 the ship was in latitude  $81^{\circ}5'32''N$ . and might have gone farther north if it had been desired. From an altitude of 300 feet on Walden Island (Waldenöya), where some stores were landed and which yielded no sign of an anchorage, the explorers "had a clear and extensive view of the Seven Islands (Sjuöyane) and thought that they saw land to the east, but that was a mistake. Next the ship visited Little Table Island (Lille Tavleöya), where some stores were landed, but where no anchorage was found.

Back at Verlegen Hok, Parry examined Treurenborg Bay (Sorgfjorden) from a boat and decided that a cove on the eastern side would serve his purpose, after cutting a canal of some 1,300 feet. There on June 21 the ship was anchored and made fast to the shore. *Hecla* Cove served Parry well, but in this respect he was lucky. No whaler would have risked his ship in this long inlet on the eastern side of the Verlegen Hook Peninsula (Mosselhalvöya). In a bad or even normal ice year a vessel might easily be trapped there and held at least a year. "The main object of our enterprise now appeared almost within our grasp, and everybody seemed anxious to make up by renewed exertion for the time we had unavoidably lost." Next day

Parry landed a launch and stores with a view to making the polar party independent of the ship in case the ship was driven to sea and lost touch with. Lieutenant Foster was put in charge of the *Hecla* and ordered to ship ballast equal in weight to the stores, etc., that were landed. He was then, during the absence of Parry and his party, "to proceed on the survey of the eastern coast", but to relinquish this survey if he thought that the ship was in danger. "I also gave directions that notices should be sent in the course of the summer to the various stations where our depots of provisions were established, acquainting me with the situation and state of the ship, and giving me any other information which might be necessary for my guidance on our return from the northward." Thus Parry showed his habitual care and provision against possible accident.

On June 21, 1827, Parry left his ship and set out for the Pole. He took two boats, the *Enterprise* and the *Endeavor*. He was in charge of one and Lieutenant Ross of the other. Each boat had also a second officer and ten men. The boats, which were built of thin planks of oak and ash, sheets of waterproof canvas, and thick felt could also be used as sledges. Provisions for 71 days were taken, "which, including the boats and every other article, made up a weight of 260 pounds per man. Lieutenant Crozier in one of the ship's cutters went with the polar party as far as Walden Island to carry some of the weight and to place a third store of provisions on Low Island (Lågöya). The rough nature of the ice and the amount of open water had made it clear that neither wheels nor reindeer would be of any use. Therefore the reindeer were left behind.

The next day the party left Low Island, still in fine weather but with much ice about. There were many walrus, but "we were very well satisfied not to molest them, for they would soon have destroyed our boats, if one had been wounded; but I believe they are never the first to make the attack." The boats served well but were very heavy to row. Walden Island, where they parted with Crozier's cutter, afforded a short rest and at Little Table Island (Lille Tavleöya) the cache of stores was resecured against bears. Parry directed Crozier to arrange that a spare boat be placed on Walden Island. At midnight on June 23 the boats were in latitude 80° 51' 13" N. and making good progress with a notable east-setting current. The weather soon became thick and the pack ice closer but a little to the west clear water was found and progress made to the northwest.

Parry explains the system of traveling which he had proposed to follow. In order to avoid the glare and to have warmer conditions for sleeping, he had planned to travel by night—there was no darkness—and to rest by day. Also there was the hope that the snow surface of the floes would be harder with a lower sun. Sleeping clothes were furs and traveling clothes were box cloth. The sails were spread over the boats as awnings at the time of supper and sleep. The temperature during sleep was 36° to 45° F. and occasionally higher. Sleep was for 7 hours. The allowance of provision for each man per day was 10 ounces of biscuit, 9 ounces of pemmican, 1 ounce of sweetened cocoa powder, 1 gill of rum, and 3 ounces of tobacco a

week. Fuel consisted of spirits of wine (alcohol), of which the daily allowance was 2 pints.

On the evening of June 24 began the laborious travelling over the rugged pack ice; sometimes three or even four journeys over the same ice had to be made. Progress was very slow; by 5 a.m. on June 25 Parry estimated that they had made about 2.5 miles of northing since taking to the ice. At noon they were in latitude  $81^{\circ} 15' 13''$  N. June 26 was a day of rain which made moving very uncomfortable and added to the difficulty that the rough surface presented. It became so bad for travelling that they halted at midnight and did not proceed again till the following evening when a change of wind drove the pack together instead of tending to disperse it. On June 28 they came "to a floe covered with high and rugged hummocks which offered a formidable object to our progress and necessitated a circuitous route." On June 29 when they halted at 2 a.m. they had made about 1.25 miles of northing in 6 hours and in a full day's work made only 2.5 miles in all. On June 29 they had reached by midnight latitude  $81^{\circ} 23' \text{ N.}$ , or a gain of only 8 miles of northing in 4 days.

And so the hopeless task went on. They rowed at times but not always to the north; more often they climbed hummocks or floundered through deep snow or slush; sometimes it rained, often it snowed. On July 1 they reached latitude  $81^{\circ} 30' 41'' \text{ N.}$  Generally "as soon as we landed on a floe Lieutenant Ross and myself went on ahead, while the boats were unloading and hauling up, in order to select the easiest road for them," and they frequently climbed hummocks of 15 to 25 feet to survey the possibilities of the route. And so these enthusiasts went on, never giving up the hope of accomplishing their task. A few birds noted in Parry's diary alone broke the monotony of ice, water, snow, rain, and fog. On July 5 they had reached latitude  $81^{\circ} 45' 15'' \text{ N.}$  The labor of the journey became worse, not easier, and they never reached the main ice or continuous floes which they expected. On July 7, when they made one of their frequent launchings, not a large or level piece of floe was to be seen to the north. The idea of the main ice came from the Phipps expedition, "one continuous plain of smooth unbroken ice, bounded only by the horizon." As a permanent feature this does not exist, though in occasional years it may occur over limited areas. The warmth of the weather and the frequency of rain also surprised Parry, and added greatly to the difficulties of travel.

It seems to have been early in July that Parry began to fear that, owing to the south-setting drift, his task was immensely more difficult than he had contemplated. On July 17 he noted that, in spite of walking a mile northward, his evening and noon positions were practically identical. Southerly winds alone checked this unwelcome drift and the frequency of southerly winds was surprising. These winds and the high temperatures suggest that Atlantic low pressure areas were strongly invading the Arctic Ocean that month. The current from a northerly direction is now known to be caused by the prevailing winds and currents from the Arctic Ocean. But of this circulation Parry was entirely ignorant. Despite his failure other

later explorers attempted the same route and naturally had no success. O. Torrell in 1858 proposed to repeat Parry's plan, but gave it up owing to unfavorable ice; A. E. Nordenskiöld in 1865 and in 1872 proposed the same route to the Pole. It was not until the drift of Nansen's *Fram* in 1895-96 that this opposing current was firmly established.

On July 20 Parry noted "how great was our mortification in finding that our latitude, by observation at noon, was only  $82^{\circ} 36' 52''$ , being less than 5 miles to the northward of our place at noon on the seventeenth." Occasionally they had a few hours of good fortune. On July 22 level floes and convenient lanes of water gave an advance of 10 to 11 miles but a net gain of only 4 miles. Soon they were actually losing northing. Parry realized that the southward drift "put beyond our reach anything but a very moderate share of success in travelling to the northward." The 83rd parallel was accepted as the limit. To reach that would use up half the supplies, break all records, and qualify the party for the bonus offered by the British Government. The highest latitude actually gained was  $82^{\circ} 45' N.$  at 7 a.m. on July 23; "at the extreme limit of our journey, our distance from the *Hecla* was only 172 miles." The whole distance covered, including relays, was 668 statute miles. The party had a day's rest in fine weather round about their north record and then turned southward (July 27). The return journey was easier and more use could be made of the boats. Always keen to use as food any seal encountered, the party also had a particularly acceptable meal from a large bear. On August 11 they gained open water in latitude  $81^{\circ} 34' N.$ , and the following day landed on the most northerly islet of the Spitsbergen group, in latitude  $80^{\circ} 50' N.$ , which Parry named Ross Island after his former commander. On the 15th they were at Low Island and 6 days later reached the *Hecla* in good condition with no casualties. Parry's venture, doomed to failure from the start, made a northern record that was not beaten until 1875 when P. Aldrich of the Nares Expedition reached latitude  $82^{\circ} 48' N.$  in Grinnell Land (Ellesmere Island).

During Parry's absence Foster had made a chart of Treurenburg Bay and had surveyed Hinlopen Strait (Hinlopenstretet) as far as latitude  $79^{\circ} 33' N.$ , which is about the latitude of the Foster Islands (Fosterøyane). The features of the early Dutch maps were all recognizable even if the latitudes and longitudes were at fault. Around Hecla Cove game was fairly abundant and offered ample fresh meat during the summer. Foster and his men shot 70 reindeer and 3 bears. The *Hecla* sailed, homeward-bound, on August 28 via Red Beach and anchored in the Thames on October 6. And so ended the polar voyage of one of the most determined and successful of all polar travelers.

On his return Parry resumed the duties of hydrographer, a post that he kept until 1829. In that year he was knighted and awarded an honorary D.C.L. by the University of Oxford. His friend Franklin received a degree on the same occasion. He then accepted a post as Commissioner of the Australia Agricultural Company in New South Wales, with headquarters

at Carrington, Port Stephens, about 90 miles north of Sydney, the settlement of this colonizing company with its million acres. Parry found the territory "a moral wilderness" but in 5 years his energy and orderly mind had worked wonders in the way of productive settlement and good government. After 5 years Parry, his wife, and four children returned to England, largely on the grounds of ill health; the Australian work had been a great strain on his constitution. He looked around for some less exacting work and in March 1835 was appointed Assistant Poor-Law Commissioner in Norfolk, being chosen from a thousand candidates. The work, however, was too arduous, and in 1836 Parry resigned. In that year he was promoted to captain and for a short time was employed by the Admiralty in organizing the packet-boat service between Liverpool, Holyhead, and Dublin. In the next year, 1837, another and more important post was made for him as head of a new department of the Admiralty under the title of Controller of Steam Machinery. Many years earlier, in fact in 1813, Parry wrote: "I have this morning been to see the block machinery worked by steam in the dockyard. . . . I never before saw a steam engine . . . I am confident that if we live 20 years, we shall use steam applied to a hundred different purposes on board a ship. . . ." Parry's former interest in the Caledonian Canal in the Highlands of Scotland led to his being employed by the Government in 1841 in drawing up a report on the canal and its probable value. This meant visits to most Scottish and many English ports, and, of course, to the canal works. His report led to the completion of the canal and its opening in April 1847.

Parry's health was now poor and he went to live at Hampstead, London, which has always had a reputation for salubrity. An operation improved his health for a time and he continued his work as Controller of Steam Machinery: "The screw propellor (was) now justly regarded as indispensable in every man-of-war" (1845). He took an active part in the preparation of the *Erebus* and the *Terror* which sailed in May 1845 under Sir J. Franklin to make the Northwest Passage. "Again, my dear Parry, I will recommend my dearest wife and daughter to your kind regard," wrote Franklin on the eve of sailing. Some years later his advice was again in demand in search operations.

The strain of work was telling on Parry and in 1846 he thought of retiring, but the Admiralty appointed him Captain Superintendent of the Naval Hospital at Haslar, Gosport. There he spent 6 busy years. In 1852, he was promoted Rear Admiral and then went to live at Bishops Waltham in Hampshire. During the year he resided there came the news of Sir H. M'Clure's triumph in finding the Northwest Passage. In 1854, he was appointed Lieutenant Governor of Greenwich Hospital. By all accounts his period of administration was a happy and useful one. Parry, however, was far from well. The year 1854 was marked by a cholera epidemic in parts of London and, while it is not certain that Parry suffered from that affliction, he was advised to consult certain doctors abroad. In June 1855

he reached Ems but all efforts were unavailing and Parry died there on July 8, 1855. He was buried at Greenwich.

The name of Parry Mountains was given in 1841 by J. C. Ross to a "range" in the Antarctic running southward from Cape Crozier near the volcanoes of Erebus and Terror. The range does not exist. The most important geographical feature named for Parry is the Parry Islands (now part of the Queen Elizabeth Islands) in the Canadian Arctic Archipelago, which include Cornwallis, Bathurst, Melville, Eglinton, and Prince Patrick islands. Parry himself originally called these the North Georgian Islands.

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- 1824-5. *Journal of a second voyage . . . performed in the years 1821-23*. . . . London: J. Murray, 2 vols., 571 + 432 pages.
- 1826. *Journal of a third voyage . . . performed in the years 1824-25*. . . . London: J. Murray, 327 pages.
- 1828. *Narrative of an attempt to reach the North Pole in the year MDCCCXXVII*. . . . London: J. Murray, 229 pages.
- Ross, John. 1819. *A voyage of discovery . . . in H.M.S. Isabella and Alexander*. . . . London: J. Murray, 252 pages.

## REVIEWS

### THE POLAR REGIONS IN THEIR RELATION TO HUMAN AFFAIRS

By LAURENCE M. GOULD. Bowman Memorial Lectures, Series 4. *The American Geographical Society, New York, 1958. 9 x 6 inches; iv + 54 pages, Appendix, 20 figures, 3 sketch maps; \$3.50.*

This, the fourth lecture in the series presented as a memorial to the late Isaiah Bowman, is the second to be of particular interest for readers of *Arctic*. Many will already be familiar with the earlier address "Glacier Variations and Climatic Fluctuations" by Professor H. W. Ahlmann of Stockholm.

The American Geographical Society has a long-established interest in arctic research and exploration, and one of its publications, "Problems of Polar Research", remains well worth consulting even 30 years after its first appearance. In the preface to that book Dr. Bowman wrote: "a world conference on objectives in polar research seems eminently desirable". Whereas no such conference has yet been called, the many meetings required to organize polar aspects of the International Geophysical Year and its "continuation" have in effect provided an international scientific consultative body, in this way achieving the ends Dr. Bowman presumably had in mind.

Laurence M. Gould provides in his own career a link both with polar activities in the late 1920's, and with the recent I.G.Y., during which he served as Director of the United States Antarctic Program. It is, therefore, natural that his lecture should touch on the early years of polar exploration, the subsequent economic developments; and also the I.G.Y. activities, which were going on when the lecture was delivered in January 1958. As his title emphasizes the author is more concerned with the significance of the polar

regions in human affairs than merely with their utility as a great geophysical laboratory.

The book falls naturally into several distinct parts. Most important is, of course, the full text of the original lecture, which is here divided into three chapters: "The North Polar Lands", "The South Polar Lands", and "Antarctica in the I.G.Y.". Noteworthy for its own sake is a group of twenty photographs, chosen to reveal the polar regions as they are today. This is not the traditional mixture of seals, polar bears, igloos, Eskimo, icebergs, and penguins. We see instead an "aerobee" rocket carrying scientific instruments being fired from Churchill; a view of Isachsen weather station on one of the Queen Elizabeth Islands; a P2V aircraft arriving from New Zealand at the Ross Island sea-ice runway in Antarctica; scenes of modern antarctic whaling; and dairy cattle in the Matanuska Valley of Alaska. Several new maps also make a distinct contribution. They include one of the North Polar Lands, illustrating the limits of the Arctic and Subarctic, and the distribution of scientific stations participating in the I.G.Y. program. Unfortunately, the excessive reduction of this map may make it necessary for some readers to use a magnifying glass to obtain full benefit from the data shown. A corresponding map of Antarctica employs the "Antarctic Convergence" (the belt surrounding the antarctic continent where water of low salinity and low temperature sinks below the more saline and warmer surface layers of 800 m. to 1200 m. thickness) as an outer limit, and also shows the participating stations operated by the twelve nations sharing in the I.G.Y. program. The next map combines two seemingly unrelated factors and in so doing draws attention to a third. It shows "Political

Claims on the Antarctic Continent", and "Accessibility of the Antarctic Coast". The former recalls the traditional territorial claims of New Zealand, Australia, Norway, and the United Kingdom and by less bold lines, those of France, The Argentine, and Chile. In drawing this distinction the cartographer has, perhaps unintentionally, stressed a very real difference that is often overlooked. The historical record suggests that the claims of the four nations first listed are grounded on scientific and administrative activity over a considerable number of years, whereas a degree of recognition has been granted the last two largely because of their fortunate location in the Western Hemisphere. The sector of Antarctica still without a claimant (that between 90°W. and 150°W.) is revealed as the only one with a coast shown for its entire length as "inaccessible to unre-enforced surface vessels in southern summer". Much of it could in fact be shown simply as "inaccessible from the sea"; it has remained unclaimed, and to a considerable extent unexplored, largely for this reason.

A new bathymetric map of the Polar Basin on a scale of 1:25,000, printed in colour, is a valuable extra dividend included in the book. It is the first such map to show relatively recent discoveries concerning the topography of the sea-bottom in the central arctic basin. Acknowledgement is made for much of the detail to a 1957 publication by Dr. V. F. Burkhanov of the Soviet Northern Sea Route Administration. The reviewer believes that it is regrettable that the compiler of the map was permitted to label the ridge extending from the New Siberian Islands to Ellesmere Island "Lomonosov or Harris Ridge". In using the first name the Soviet discoverers paid tribute to an outstanding 18th-century Russian scholar, as it was their privilege to do. The wholly gratuitous addition of the second name adds nothing to the scientific reputation of Harris, but may serve to convince Soviet scientists that some enthusiasts for the cold war see even in submarine topography an excuse to do battle. This comment in no

way reflects on Dr. Gould, whose text makes no mention of the map, and who, on the contrary, is always generous in his references to other countries. The same map introduces the term "Laurentian Basin" for a depression west of Ellesmere Island. The reason for the term is obscure and it can be criticised as being remote indeed from the point of origin of the term "Laurentian".

An Appendix "Sovereignty in Antarctica" records the pertinent data, including essential documents, supporting the claims of seven nations to territory on the antarctic continent itself, and of others to off-lying islands. Still other nations, six in number, with antarctic interests but no formal claims, are also included; outstanding among them are the United States, U.S.S.R., and Japan.

The text of Dr. Gould's lecture, which was delivered in the attractively informal style that so many of us have learned to admire, is a valuable summary of the present situation in the polar regions. In discussing the North it stresses development of resources and strategic considerations, and the concluding sentences of this section deserve quotation as reflecting the views of scientists of all nations whose work has taken them into the region:

"It is tragic that the real possibilities for economic development should be over-shadowed and obscured by the defence preparations I have described. Granted peace, the economic strategic importance of the northlands will exceed their military significance."

Antarctica provides scope for only a brief discussion of the development of natural resources, in which the important whaling industry is mentioned. It may be worth while, in the face of a good deal of rather loose talk to the contrary, to quote the author's view on antarctic minerals: "At the present time we know of no commercial deposits of any mineral whatsoever in Antarctica". Whereas there is little new that can usefully be written about sovereignty in the Arctic, this subject continues to be a source of controversy

in the Far South. Even the claim to be discoverer of the continent itself is disputed—more usually between supporters of Britain's Bransfield and United States' Palmer, although in the latter case a fellow American, Burdick, has also become a contender. In recent years the Soviet Union, not to be outdone, has suggested that the Czarist admiral von Bellingshausen is the rightful claimant. However, as Dr. Gould implies, it is surely more important to discuss the future of the area than details of its remote past. In this "the successful co-operation of the I.G.Y. in Antarctica" may not only ensure that its scientific secrets will be uncovered for the good of all, but also that the collaboration so achieved may provide a much needed example to nations in other parts of the world.

TREVOR LLOYD

#### OCEANOGRAPHIC ATLAS OF THE POLAR SEAS, PART II, ARCTIC

H. O. Pub. 705, Washington, D.C.: U.S. Hydrographic Office, 1958. 12½ x 16 inches; 143 pages, 132 figures; \$5.00.

The Oceanographic Atlas of the Polar Seas, Part II, Arctic will be released for distribution in June 1959. It completes the first oceanographic atlas in a series, which will ultimately cover all ocean areas. Part I, covering the antarctic region, was published in 1957 and is now in its second printing.

Previous to this compilation no atlas provided such comprehensive coverage of all elements of the marine environment of the arctic regions; although there are a number of excellent publications prepared by various countries, which cover selected areas of the Arctic, or treat special topics only, such as ice, of the entire area.

The preface introduces Part II with a recapitulation of arctic explorations by the United States, beginning with the expeditions of Griffin, DeHaven, and Kane, into the Davis Strait-Baffin Bay area together with some passages of the Canadian Arctic Archipelago while searching for the ill-fated Franklin Expedition in the mid-nineteenth century.

The scientific achievements of the search expeditions and of later United States expeditions to the Arctic were primarily of a geographical nature, but included some information on natural history subjects. Only in recent years has the emphasis been placed on the study of the environment. Since World War II sustained efforts by the United States and other nations in oceanographic and meteorological research have added materially to our knowledge of the arctic environment.

Charted information is presented in the atlas on a monthly or seasonal basis depending on the distribution and the manner of variation of the particular environmental element. Charts in the atlas were prepared during 1957 and early 1958 from all data then available. The atlas is divided into seven sections, and there is a bibliography of 125 major reference sources.

In the section on tides and currents data are presented on charts showing tidal types; co-tidal lines; tide range; general surface circulation; surface currents of parts of the Arctic Ocean and adjacent waters; major drifts of vessels and ice islands; circulation of Atlantic water in the Arctic Ocean and adjacent seas; and the dynamic topography of the Greenland-Norwegian Sea. Physical properties, such as temperature, salinity, density, water colour, and transparency, as well as selected vertical sections are shown on other charts.

The section on ice occupies a good portion of the book and ice charts constitute about one-third of the figures. Presentations include concentration of ice and extremes of ice conditions; variability of lead width and concentration; comparison of ice conditions in 1955 and 1956; comparison of the polar pack boundaries along the Alaskan and Canadian coasts for the years 1953 to 1956; comparison of ice pack boundaries in Baffin Bay and Davis Strait for 1953 to 1956; freeze-up and break-up dates; and probability of superstructure icing. Special treatment is given to the period of ice formation. On account of the marked changes of ice conditions during the spring, summer,

and fall seasons, they are presented in biweekly charts for selected areas where observations are sufficiently numerous to allow this.

The wind, sea, and swell section gives surface wind roses and shows the state of sea, swell, accumulated heights and periods for surface waves, the directional distribution of periods, and sea heights for selected coastal stations.

Bathymetry, bottom sediments, earthquake epicentres, volcanoes, structural trends, major rock types, gravity, gravity anomalies, variation of the magnetic compass, range of disturbance in total magnetic intensity during a low sunspot year, and a chart of the auroral zone make up the graphic presentation of marine geology.

Charts showing intensity of fouling, distribution of marine algae and seagrasses, deep scattering layer, and distribution of marine mammals, are included in the marine biology section. The last section of the atlas is devoted to the distribution of oceanographic stations and bathythermograph observations.

Reliability diagrams are included for some elements. The bibliography and charts of oceanographic observations give the principal sources of the data from which the atlas was prepared in detail.

A polar projection chart (equidistant azimuthal) that extends to at least 65°N. is used as the base for the areal analyses shown in the atlas. With the exception of the ice distribution this polar base chart seems to be suitable for all presentations. For the ice section the base chart could have been extended to provide a complete coverage of ice conditions to the southernmost winter extent of ice in the Bering Sea and along the east coast of Canada.

A few large scale charts on a Mer-

cator projection are employed to present more detail. Cross-sections and histograms supplement the basic analyses of the physical properties and ice sections respectively.

For most publications the physical make-up is of little real importance other than for advertising and selling purposes; atlases, however, are in a different category in this regard, because their accuracy and utility depend to a considerable degree on their physical characteristics.

This publication is of a convenient size for desk and shipboard use, and is definitely an improvement over most previous Hydrographic Office atlases, which were extremely large and unwieldy. It is printed on high rag content nonabsorbent paper that should be serviceable for marine use. Multicolour printing is used, which allows the presentation of related parameters on one chart. The lithography in general is good. The atlas is permanently bound, but the paper cover is not in keeping with the otherwise high quality.

The price should put this publication within reach of everyone interested in polar areas. For the student it can answer almost every conceivable general question he may have on arctic marine environment; for the research worker it should serve as a basic reference book he could ill afford to overlook.

It is unfortunate that this atlas was not available prior to the I.G.Y. The charts it contains would have been very helpful in the development of the plans for various scientific endeavours. The two charts of oceanography stations are probably the best compilation available at present; they might well serve as a polar supplement to T. Wayland Vaughan's notable publication "International Aspects of Oceanography".

H. W. DUBACH

## INSTITUTE NEWS

### Gifts to the library

The Institute library acknowledges with thanks gifts of books and reprints from the following persons and organizations:

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Kungl. Vetenskapsakademiens Bibliotek, Stockholm

### Technical Papers of the Arctic Institute

No. 3 of this series, *THE VEGETATION OF NORTHERN MANITOBA III. STUDIES IN THE SUBARCTIC*. By J. C. Ritchie, 56 pages, maps, diagrams, tables, and plates, has

appeared. Copies can be obtained from the Montreal Office at the price of \$1.00 to members, \$2.00 to non-members.

### Award of Institute grants

The following have been awarded research grants by the Institute for 1959 from the Sir Frederick Banting Fund, The Ellsworth Foundation, funds of the Institute and through contract with the United States Office of Naval Research:

ALI, M. A. McGill University, Montreal, P.Q., Canada.

A histo-physiological study of the reaction of the eye in *Gammarus* to different light and temperature conditions and its comparison with their behavioural responses and rates of oxygen consumption at Churchill, Man.

APOLLONIO, S. Yale University, New Haven, Conn., U.S.A.

Study of the summer primary organic productivity of fresh and salt waters of the High Arctic at Alert, Ellesmere Island.

BARNES, C. A. University of Washington, Seattle, Wash., U.S.A.

Compilation of oceanographic data at the library of the University of Washington.

CAMPBELL, J. M. Yale University, New Haven, Conn., U.S.A.

Excavation of two archaeological sites at Anaktuvuk Pass, Alaska.

DEAN, F. C. Dept. of Wildlife Management, College, Alaska, U.S.A.

Continuation of study of grizzly bear at Mt. McKinley, Alaska.

DRIVER, P. M. McGill University, Montreal, P.Q., Canada.

Continuation of study of ethology and ecology of Mergini at the Belcher Islands, Hudson Bay.

FISHER, A. K. State University of Iowa, Iowa City, Iowa, U.S.A.

Study of the rates of oxygen consumption in tissues of arctic mammals at Barrow, Alaska.

- FREEMAN, M. M. R. McGill University, Montreal, P.Q., Canada.  
An ecological survey of the littoral and shallow-water fauna of the Belcher Islands, with particular reference to the seal population of the region.
- GAGNÉ, R. C. University of Montreal, Montreal, P.Q., Canada.  
Studies in structural linguistics with special application of its principles to an interdialectal survey of Eskimo phonology, morphology, and morphophonology to advance the project of orthographic unification on a scientific basis.
- GEIST, O. Wm. University of Alaska, College, Alaska, U.S.A.  
Study of Pleistocene fossil deposits at Barrow, Alaska.
- HUSSEY, K. M. Iowa State College, Ames, Iowa, U.S.A.  
Continuation of study of geological-geomorphological relationships at Barrow, Alaska.
- IRVING, Wm. N. Smithsonian Institution RBS, Lincoln, Neb., U.S.A.  
Preparation for publication of field data and collections from early tundra culture sites on Itivlik Lake, Brooks Range.
- KARLSTROM, E. L. Augustana College, Rock Island, Ill., U.S.A.  
Ecological and systematic study of the amphibian *Bufo boreas* at Prince William Sound, Alaska.
- KREBS, Ch. J. University of British Columbia, Vancouver, B.C., Canada.  
A study of the population dynamics of the collared lemming (*Dicrostonyx groenlandicus*) with particular emphasis on the role of stress and the endocrine system in controlling fluctuations in numbers, Baker Lake, N.W.T.
- LØKEN, O. H. McGill University, Montreal, P.Q., Canada.  
Study of glacial geology in a small area especially with regard to deglaciation process and evidence of local glaciation later than the continental one, Torngat Mountains, Labrador.
- MAHER, Wm. J. University of California, Berkeley, Calif., U.S.A.  
Continuation of study of pomarine jaeger population at Barrow, Alaska.
- MILLER, M. M. Columbia University, New York, N.Y., U.S.A.  
Investigation of geophysical character of thermal regimen of two highland polar glaciers, Ellesmere Island.
- MORTENSON, E. McGill University, Montreal, P.Q., Canada.  
Investigation to determine the relation between daily temperature and stem elongation in *Picea glauca*, Schefferville (Knob Lake), P.Q.
- MYRES, M. T. University of British Columbia, Vancouver, B.C., Canada.  
Continuation of studies of migration and distributional ecology of eider ducks in Alaska, at Barrow.
- NUTT, D. C. Dartmouth College, Hanover, N.H., U.S.A.  
Laboratory work on Greenland gas-in-ice study 1958.
- PESSL, F. University of Michigan, Ann Arbor, Mich., U.S.A.  
Glacial geology and general geomorphological studies, Sortehjorne, Greenland.
- PITELKA, F. A. University of California, Berkeley, Calif., U.S.A.  
Continuation of studies of comparative ecology of lemmings and other microtines, Barrow, Alaska.
- PORTER, S. C. Yale University, New Haven, Conn., U.S.A.  
Study and mapping of bedrock and Pleistocene geology at Anaktuvuk Pass, Alaska.
- POST, A. S. University of Washington, Seattle, Wash., U.S.A.  
Preparation of report on geographical position and extent of all existing glaciers in the Brooks Range.
- POWELL, J. M. McGill University, Montreal, P.Q., Canada.  
To continue the collection of plants and study of vegetation in the Lake Hazen area and to extend the survey to Alert. Microclimatological observations and phenological records will be kept and an investigation made of 30 species found at Lake Hazen in 1958 but as yet unknown farther north.
- PRESCOTT, G. W. Michigan State College, East Lansing, Mich., U.S.A.  
Limnological and biological survey of arctic lakes at Barrow, Alaska.

SAGAR, R. B. McGill University, Montreal, P.Q., Canada.

To conduct glacial-meteorological observations at Gilman Glacier snout during the 1959 ablation season as a continuation of studies by D.R.B. "Operation Hazen" parties in 1957-8. Complementary observations to include a survey of the ice-land zone, accumulation/ablation data at previously established glacier stations and a comparative study of nearby glacier snouts.

SATER, J. E. 840 N. Park St., Columbus, Ohio, U.S.A.

Study of photogrammetric and photo interpretative analysis of sea ice at Barrow, Alaska.

SCHALK, M. Smith College, Northampton, Mass., U.S.A.

Continuation of comparative study of origin and history of beach systems at

Barrow, Alaska.

SCHOLANDER, P. F. Scripps Institution of Oceanography, La Jolla, Calif., U.S.A. Study of physiological adaptations of marine fishes and algae to life under arctic sea ice at Hebron Fiord, Labrador.

SHANKS, R. E. University of Tennessee, Knoxville, Tenn., U.S.A.

Continuation of investigations of composition, structure, and productivity of tundra vegetation, Barrow, Alaska.

SHETLER, S. G. University of Michigan, Ann Arbor, Mich., U.S.A.

Studies of populations of *Campanula rotundifolia* along the Alaska Highway.

TEDROW, J. C. F. Rutgers University, New Brunswick, N.J., U.S.A.

Continuation of study of pedological processes operating in arctic areas in Alaska, Barrow and vicinity.

## NORTHERN NEWS

### A project to unify the orthography of the Eskimo language

In Canada several systems of writing the Eskimo language are in use at present. There is the syllabic system (using as signs small triangles, right angles, acute angles, semicircles, etc.) used by the great majority of the Eskimo people, and several alphabetic systems based on roman letters. The syllabary is known wherever missionaries have been teaching, except in Labrador and the Mackenzie River region, where only alphabetic systems are taught. The syllabary is also unknown in Greenland. Those who know both the syllabics and the alphabet are still a small minority. The writing symbols used by an individual Eskimo

depend largely on his place of origin and his teacher, usually a missionary. Of the forty-eight symbols of the syllabarium normally only thirty-six are used by the Eskimo east of Hudson Bay, whereas those to the west of the Bay manage with thirty-two. The differences in the alphabetic systems are much more varied. In any event, none of these orthographies is common to all Eskimo.

The increasing frequency of contact between Eskimo and Whites has shown the importance of efficient communication between the two groups in recent years. Government bulletins have been published in the Eskimo language using both the syllabic and alphabetic spellings. The general confusion and practical difficulties resulting from the

coexistence of numerous writing systems soon made themselves felt in government circles and it became necessary to attempt a solution of this problem. Through the initiative of Mr. G. Rowley, Secretary, Advisory Com. on Northern Development in the Department of Northern Affairs and National Resources in Ottawa, the question was handed to Dr. Gilles Lefebvre, a linguist at the University of Montreal, for investigation on a scientific basis. It was hoped that linguistic research would show that a standard spelling can be designed for all Canadian Eskimo, and that a new alphabet could perhaps approximate that used in Greenland. This would enable the Canadian Eskimo to benefit from the considerable body of Greenlandic literature and lead to a cultural rapprochement between the two groups of common ancestry.

When this project got under way I was a student of Eskimo linguistics at the University of Montreal under Dr. Lefebvre, who asked me to collaborate with him. It was decided that a detailed phonemic analysis of one dialect would be a necessary first step in a comparative interdialectal survey leading to orthographic unification. Financial assistance from the Department of Northern Affairs and National Resources and the Arctic Institute of North America enabled me to undertake this research program. In September 1958 I presented the results of this investigation as an M. A. thesis entitled: "A phonemic analysis of an eastern Hudson Bay Eskimo dialect with special reference to orthographic unification".

In the first part of the thesis the phonemes or basic functional sounds of the Inukjuarmiut dialect, spoken by the people of Port Harrison, are presented, supported by linguistic and kymographic data. In the second part the theoretical basis of the general framework of the proposed new alphabet is discussed. Several major problems were discovered in the course of the analysis, which point to the need for further investigation before definite conclusions can be reached with regard

to orthographic standardization. The interdialectal differences form the basis of these problems, which can only be alluded to here. There is the question of diaphones (different pronunciations of the same word in different dialects), the problem of morphophonemic transformations, which vary in certain dialects, and the difficulties created by the final consonants, which are heard in some regions, are latent in others, and completely non-existent elsewhere. The selection of the criteria to be used to overcome the many interdialectal differences in the new standard spelling is a matter of first importance, and because it is a highly controversial matter, great care must be taken in gathering and assessing the varied linguistic data so that the final decisions will rest on facts rather than on opinion.

In a series of three articles that I hope to submit to this journal in the course of the next year or so, I plan to give a more detailed explanation of the obstacles facing spelling standardization, and to offer certain solutions. Broadly speaking, I plan treating these subjects in the following order. First, an article in defence of a standard phonemic spelling in roman letters rather than in syllabics. Second, an exposition of the phonemic principle that plays a fundamental role in the design of an orthography that is to be clear, simple, and efficient. Since not only linguists will have a hand in this project, agreement will be impossible without a common understanding of this basic principle. Primarily such a project is the job of the linguist, but "the successful design of a written language requires thorough knowledge of the linguistic, political, and practical aspects of the problem. Hence it requires co-operative work by linguists, anthropologists, administrators, missionaries, and native leadership." (Gleason, H. A. *An introduction to descriptive linguistics*. New York 1955, p. 323). Third, a presentation of a modified version of the new standard alphabetic spelling hinted at in my thesis, on the basis of my new findings since I have been studying at the

Sorbonne, and of the research that I shall be doing on Greenlandic at the University of Copenhagen next year.

The object of my present studies at the Sorbonne is to examine the various linguistic theories and to try to apply them to the solution of the many practical spelling problems. On pursuing my studies of Greenlandic in Denmark next year, I hope to assess to what extent the new Canadian Eskimo orthography can approximate the Greenlandic one. Some Greenlanders are considering slight spelling reforms that would bring their writing system much closer to the one considered for Canadian Eskimo. Any step in this direction will be welcomed by all those seeking closer ties between the two groups.

Thus far my personal experience has led to the conclusion that, whatever the cost, the design of a standard orthography should not be introduced prematurely for reasons of expediency, because, as Gleason says, the design of an orthography is a difficult and intricate matter.

RAYMOND C. GAGNÉ

#### Correction

In Sir Hubert Wilkins's obituary (*Arctic* 11:259) it had been erroneously stated that Sir Hubert died in New York. Actually he died in Framingham, Mass., where he had lived since 1953, while working for the Quartermaster Research and Engineering Command, U.S. Army, at Natick, Mass. He had served with the Quartermaster Corps and Department of the Army as consultant and arctic expert since the beginning of World War II.

The second sentence of paragraph four of the obituary should read: "He was second in command of the northern party of the Canadian Arctic Expedition 1913-18 under Stefansson".

The following, taken from the *London Times* of March 28, 1959, may be of interest. During a second cruise under the arctic ice pack the U.S. nuclear submarine *Skate* surfaced on March 17 at the North Pole. There the vessel's company under Commander James Calvert held a service in memory of Sir Hubert. In compliance with one of his last wishes his ashes were then scattered in the driving snow.



Rear Admiral L. O. Colbert, former Director, Washington Office of the Arctic Institute.

### L. O. Colbert

On December 31, 1958 Rear Admiral Colbert retired from the Directorship of the Institute's Washington Office, a post he had held since February 1952 and to the responsibilities of which he brought the fruits of a long life of scientific and administrative distinction.

The Washington Office had been established scarcely a year when its then Director, Lincoln Washburn, gave up his close association with the Institute to carry forward his long-time interest in geomorphological field research. The task of replacing him in the Institute family seemed an impossible one, yet, by great good fortune, his leaving us coincided with the retirement of Admiral Colbert from government service as Director of the U.S. Coast and Geodetic Survey. Because of his many seasons of scientific work in Alaska and Alaskan waters and his interest in arctic oceanography and related disciplines, Lee Colbert was persuaded to apply his wide experience to the needs of the young and growing Arctic Institute.

The prestige and respect he had earned through association with a wide circle of scientific and administrative colleagues in Washington immediately redounded to the Institute's credit. The polar regions were at that time becoming intensely spotlighted, and Admiral Colbert was able to bring to our objectives the interest and wise counsel of many individuals and agencies, the benefits of which are embodied in our present research program. It is fair to say also that the "meetings of minds" that he stimulated enhanced not only our own scientific objectives but served to acquaint our counsellors with each others' programs, thus providing a useful catalytic function and the strengthening of arctic programs carried out by other national groups.

To the sea and its problems Admiral Colbert brought eager enthusiasm, and his efforts in our interests and the expansion of our long-time association with the Office of Naval Research and in the Institute's advisory role in the research programs of the Arctic Research Laboratory at Point Barrow, Alaska. Always a strong advocate of fundamental tools for the scientist, he gave much of himself to the problems of compilation and publication of the *Arctic Bibliography*, seven volumes of which reached the scientific community during his directorship. No less was he instrumental in the appearance of the Institute's volume, *Arctic Research*, to which he contributed the chapters "Geophysical Research in Alaska" and "Tidal Data in the North American Arctic". If these contributions are tangible monuments to his devotion to Institute affairs, the intangibles must be the gratitude of more than one hundred and sixty principal investigators sponsored by the Institute whose field programs assisted and guided to completion. Nor did the Admiral's encouragement benefit only the senior investigators, for these mature scientists he took somewhat for granted. Far more he relished the opportunity to develop the talents of younger men and to steer an ever increasing flow of scientific potential toward the future needs of polar research.

Those of us in the Institute who have had the pleasure of close and happy association with Admiral Colbert will wish him well in his "retirement", for we know that there is no such word in his vocabulary. Rather we relish the prospect of his wise counsel and active interest in Institute affairs for many years to come.

WALTER A. WOOD

## GEOGRAPHICAL NAMES IN THE CANADIAN NORTH

The Canadian Board on Geographical Names has adopted the following names and name changes for official use in the Northwest Territories and Yukon Territory. For convenience of reference the names are listed according to the maps on which they appear. The latitudes and longitudes given are approximate only.

### La Biche River, 95 C

(Adopted May 1, 1958)

Larsen Creek	60°10'N.	125°01'W.	
Fantasque Lake	60°15'	124°56'	
Jackpine Lake	60°39'	125°43'	
Spruce Lake	60°51'	125°51'	
Liard Plateau	60°23'	125°15'	
Babiche Mountain	60°17'	124°22'	
Chinkeh Creek	60°35'	124°02'	
Murky Creek	60°43'	124°03'	
Sully Creek	60°39'	124°06'	
Tika Creek	60°44'	124°43'	
Dendale Lake	60°47'	124°52'	
Etanda Lakes	60°50'	124°23'	
Pool Creek	60°23'	125°35'	
Gold Pay Creek	60°23'	125°22'	
Kotanelee Range	60°40'	124°12'	
Meilleur River	60°55'	125°40'	not Meilleur Creek
Whitefish River	60°12'	125°04'	not Thatanili River
			nor Tzenda River
Balsam Lake	60°50'	125°57'	not Porcupine Lake
Lookout Mountain	60°51'	125°57'	not Porcupine Mountain
Altered application			
Tlogotsho Mountains	60°55'	124°35'	
(Adopted July 3, 1958)			
Name Change			
Tlogotsho Range	60°50'	124°30'	not Tlogotsho Mountains

### Anderson River, 97 SW. and 97 SE.

(Adopted July 3, 1958)

Letty Harbour (settlement) 69°52'N. 124°36'W.

### St. Elias, 115 SW. and 115 SE.

(Adopted July 3, 1958)

North Gemini (peak)	61°19'N.	140°51'W.	
South Gemini (peak)	61°19'	140°51'	
Ice Fall Peak	61°18'	140°52'	
Snowfield Peak	61°15'	140°46'	
Avalanche Peak	61°14'	140°44'	
Mount Black	61°14'	140°42'	not Mount Fermi
Mount Macaulay	61°13'	140°31'	not Mount Planck
Mount Slaggard	61°11'	140°34'	not Mount Einstein
Solomon Peak	61°16'	140°00'	not Angeles Peak
Mount McBride	61°19'	140°42'	not Mount Hubble
Altered applications			
Mount Wood Glacier	61°21'	140°36'	
Brabazon Glacier	61°22'	140°41'	

### Fort Selkirk, 115 NW. and 115 NE.

(Adopted July 3, 1958)

Glenboyle (locality)	63°59'N.	138°40'W.
Flat Creek (locality)	63°56'	138°35'
Sulphur (locality)	63°45'	138°53'
Paris (locality)	63°48'	138°53'

Gold Run (locality)	63°42'	138°35'	
Thistle Creek (locality)	63°04'	139°28'	
Scroggie Creek (locality)	63°12'	138°49'	
Black Hills (locality)	63°28'	138°49'	
Britannia Creek (locality)	62°52'	138°41'	
Minto (locality)	62°36'	136°50'	
Yukon Crossing (locality)	62°20'	136°28'	
Carmacks (post office)	62°05'	136°17'	
Minto Lake	63°40'	136°18'	
Von Wilczek Lakes	62°42'	136°42'	
Tatchun Lake	62°17'	136°06'	
Towhata Lake	62°41'	136°21'	
Black Creek	62°50'	137°36'	
Wolverine Creek	62°43'	137°17'	
Dark Creek	62°31'	137°01'	
Big Creek	62°37'	137°00'	
Grayling Creek	62°41'	136°44'	
Legar Creek	62°43'	136°25'	
Ptarmigan Creek	62°43'	136°23'	
McCabe Creek	62°32'	136°45'	
Magpie Creek	62°14'	137°44'	
Bow Creek	62°18'	137°13'	
Hoochekoo Creek	62°27'	136°40'	
Williams Creek	62°24'	136°36'	
Crossing Creek	62°21'	136°28'	
McGregor Creek	62°23'	136°34'	
Murray Creek	62°09'	136°22'	
Rowlinson Creek	62°03'	136°17'	
Mount Scottie	62°48'	141°00'	
Mount Pitt	62°35'	137°35'	
Volcano Mountain	62°56'	137°22'	
Ptarmigan Mountain	62°43'	136°07'	
Syenite Range	63°58'	137°19'	
Klaza Mountain	62°16'	137°29'	
Victoria Mountain	62°11'	137°08'	
Mount Nansen	62°07'	137°18'	
Granite Mountain	62°19'	136°55'	
Tantalus Butte	62°08'	136°16'	
Bradens Canyon	62°51'	136°50'	
Granite Canyon	62°51'	136°10'	
Ingersoll Islands	62°41'	137°09'	
Grand Forks (locality)	63°50'	139°17'	
Dredge Creek (locality)	63°25'	139°12'	
Brewer Creek (locality)	63°11'	139°00'	
Ballarat Creek (locality)	62°55'	138°58'	
Gull Rock (locality)	62°51'	136°44'	
Mooseskin Rock (locality)	62°50'	136°50'	
Caribou (locality)	63°50'	138°41'	
Flat Creek (locality)	63°57'	138°35'	
Dominion (locality)	63°39'	138°36'	
Gravel Lake (locality)	63°49'	137°56'	
Stewart Crossing (locality)	63°19'	138°16'	
Readford (locality)	63°47'	139°07'	not Radford (locality)
Gold Bottom (locality)	63°58'	138°58'	not Hunker (locality)
Clear Creek (locality)	63°47'	137°16'	not Clear Creek Roadhouse (locality)
Pelly Crossing (settlement)	62°50'	136°33'	not Mica Creek (locality)
North Henderson Creek	63°23'	139°20'	not Left Fork of Henderson Creek
Nutzotin Mountains	62°00'	141°00'	not Nutzotin Range
Hellsgate (locality)	62°42'	137°15'	not Hells Gate (locality)
<i>Name confirmation</i>			
Starvation Mountain	62°44'	140°56'	
<i>Rescinded</i>			
Mirror Creek (locality)	62°32'	140°57'	

**Chart 6374, Approaches to Tuktoyaktuk Harbour***(Adopted July 3, 1958)*

Canyanek Inlet	69°23'N.	133°23'W.	
Naparotalik Spit	69°23'	133°22'	
<i>Name change</i>			
Ibyuk Hill	69°23'	133°05'	not Crater summit (hill)

*Altered application*

Peninsula Point	69°24'	133°10'
<i>(Adopted September 4, 1958)</i>		
Kittigazuit Bay	69°24'	133°46'

**Kluane Lake, 115 G**  
*(Adopted July 3, 1958)*

Klewitt Creek	61°16'N.	138°47'W.
Gladstone Lakes	61°23'	138°08'
Venus Creek	61°20'	138°09'
Venus Butte (bluff)	61°19'	138°09'
Rockslide Creek	61°28'	138°23'
Monzonite Creek	61°34'	138°06'
Dickson Creek	61°09'	138°33'

*Altered application*

Raft Creek	61°29'	138°36'
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*(Adopted December 4, 1958)**Name change*

Alaskite Creek	61°34'	138°06'	not Monzonite Creek
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**Chart 5476, Harbours and Anchorages, James and Hudson Bays***(Adopted July 3, 1958)*

Bland Island	55°15'N.	85°71'W.	
Martel Island	55°15'	85°10'	
Oman Point	55°17'	84°59'	
Hook Point	54°53'	82°13'	
Towers Creek	54°44'	82°15'	
Willow Island	52°14'	81°38'	
Clark Island	52°14'	81°35'	
Ball Island	52°15'	81°30'	
Faries Island	52°17'	81°40'	
Iserhoff Island	52°17'	81°38'	
Linklater Island	52°17'	81°36'	
Anderson Point	52°14'	81°28'	
Shave Point	54°36'	79°40'	
Polar Point	54°22'	81°05'	
Two Cubs Islands	54°20'	81°08'	
Sheldrake Shoal	54°20'	81°04'	
Whale's Back Rock	54°17'	81°08'	
Cape Jones Island	54°36'	79°47'	
George Bay	54°37'	79°42'	
Manitounuk Islands	55°24'	77°41'	
Laverock Bay	55°24'	77°40'	
Neilsen Island	55°24'	77°41'	
Maver Islands	55°20'	77°44'	
North Channel	52°17'	81°31'	not North Branch
			nor North River
South Channel	52°07'	81°35'	not South Branch
Cutaway Channel	52°15'	81°30'	not The Gutway (channel)
Fafard Island	52°18'	81°30'	not Fafard Islands
Walton Point	55°16'	77°52'	not South Point
Gillies Island	55°20'	77°52'	not Flint Island

**Chart 5475, Povungnituk Bay***(Adopted July 3, 1958)*

South Island	59°58'N.	77°33'W.	
Rock Island	59°58'	77°31'	
Shallow Bay	59°48'	77°25'	
Cairn Island	60°02'	77°15'	
North Kopak Island	60°00'	77°45'	not Split Island
Innelatevik Island	60°01'	77°23'	not Bed Island
South Kopak Island	60°00'	77°45'	not Split Island
Long Beach Island	59°58'	77°39'	not Kangasagitoo Island
Inooksulik Island	59°59'	77°27'	not Cairnet Island
			nor Inooksulikapik Island
Big Finger Point	59°20'	77°20'	not Tekegalook Point
Fish Point	60°00'	77°21'	not Pesetook Point
Fat Island	60°02'	77°17'	not Kikertakudloo Island
Big Island	60°02'	77°16'	not Kikertakalook Island

**Indin Lake, 86 B***(Adopted August 7, 1958)*

Rodrigues Lake 64°47'N. 115°38'W.

**Aishihik Lake, 115 H***(Adopted August 7, 1958)*

Mount Bark 61°05'N. 137°30'W.

MacIntosh Creek 61°57' 137°17'

Buffalo Mountain 61°54' 136°46'

Little Buffalo Lake 61°53' 136°27'

**Peel River Aeronautical Chart 2078, Area of 106 and 116***(Adopted September 4, 1958)*

Bluefish Creek 67°00'N. 133°45'W.

Jackfish Creek 66°57' 133°14'

Weldon Creek 66°25' 132°47'

Donnelly River 65°50' 128°50'

Old Crow Range 67°40' 140°30'

Keele Range 67°00' 140°00'

Bald Hill 65°48' 132°40'

Lower Beaver River 66°40' 133°00' not Lower (First) Beaver River

Upper Beaver River 66°37' 132°58' not Upper (Second) Beaver River

Nahoni Range 65°30' 139°15' not Nahoni Mountains

*Name Change**(Adopted December 4, 1958)*

Hanna River 65°41'N. 128°40'W. not East Mountain River

**Chart 6368, Approaches to Yellowknife Bay***(Adopted September 4, 1958)*

Expeditor Reefs 62°12'N. 114°12'W.

Pilot Islands 62°13' 114°06'

Jackfish Islands 62°13' 114°02'

Middle Rocks 62°11' 113°58'

Beniah Rocks 62°09' 113°58'

Beniah Islands 62°10' 113°55'

Hump Island 62°08' 113°52'

Burnt Island 62°07' 113°48'

Cabin Islands 62°06' 113°45'

Jackfish Cove 62°13' 113°56'

Moose Bay 62°12' 113°55'

Moose Lake 62°13' 113°50'

Drybones Rocks 62°07' 113°54' not Drybone Rocks

Drybones Bay 62°09' 113°49' not Drybone Bay

**Clyde, 27 NW and 27 NE***(Adopted October 2, 1958)*

Halliday Point 70°20'N. 68°02'W.

**Challenger Mountains, 49 A N½ and 39 A N½***(Adopted October 2, 1958)*

Cape Armstrong 82°07'N. 88°20'W.

Cape Woods 82°15' 87°15'

**Chart 5445, Rankin Inlet, Vicinity of Thomson Island***(Adopted October 2, 1958)*

Rankin Inlet (settlement) 62°49'N. 92°03'W.

Sanderling Island 62°51' 92°06'

Rightfoot Islet 62°51' 92°03'

Swan Island 62°50' 92°02'

Essex Island 62°49' 92°04'

First Point 62°48' 92°03'

Bunting Island 62°49' 92°02'

Leftfoot Islet 62°49' 92°01'

Suluk Islet 62°49' 92°01'

Pikuk Rock 62°48' 92°01'

Gravel islets 62°50' 91°54'

Dark Point 62°49' 91°54'

Siskin Point 62°49' 91°53'

Penny Islet 62°49' 91°53'

Panorama Island 62°47' 92°06'

Slab Island 62°46' 92°06'

Survey Point	62°48'	92°05'	
Gig Rock	62°47'	92°04'	
Cur Island	62°48'	92°02'	
Buff Island	62°47'	92°04'	
Aukpik Island	62°46'	92°04'	
Hump Island	62°46'	92°06'	
Hillock Islet	62°46'	92°05'	
Kresik Island	62°48'	92°01'	
Bag Island	62°47'	92°02'	
Guillemot Rocks	62°46'	92°01'	
Mannik Islet	62°46'	91°59'	
Crag Rock	62°46'	92°00'	
Guillemot Bank	62°46'	91°56'	
Buttress Islands	62°45'	92°10'	
Smooth Island	62°44'	92°08'	
Stickle Islet	62°46'	92°03'	
Net Island	62°46'	92°02'	
Kelp Rock	62°46'	91°58'	
Harp Rock	62°46'	91°57'	
Separation Shoals	62°45'	91°56'	
Big Pod Rock	62°45'	91°57'	
Little Pod Rock	62°44'	91°56'	
Pod Rock	62°44'	91°55'	
Middle Shoals	62°45'	91°50'	
Cygnat Lake	62°49'	92°08'	
Prairie Bay	62°50'	92°04'	
Thomson Passage	62°50'	91°57'	
Silent Cove	62°47'	92°09'	
Melvin Bay	62°48'	92°07'	
Access Passage	62°47'	92°05'	
Horseshoe Deep	62°48'	91°58'	
Char River	62°51'	92°08'	
Mittik Island	62°50'	92°03'	not Metik Island
Kudlulik Peninsula	62°48'	92°05'	not Kudlulik Peninsula
Ahigik Island	62°47'	92°12'	not Uggik Island
Tudlik Peninsula	62°47'	92°08'	not Toodlik Peninsula
Kango Island	62°46'	92°08'	not Kungo Island
Theron Island	62°47'	92°05'	not Maro Island
Guillemot Island	62°46'	91°59'	not Pitulak Island
Nipissak Lake	62°49'	92°08'	not Creel Lake
Johnston Cove	62°49'	92°04'	not Mine Cove
<b>Mayo, 105 M/12</b>			
<i>(Adopted October 2, 1958)</i>			
Five Miles Lakes	63°39'N.	135°52'W.	
Big Island	63°37'	135°46'	
Wareham Lake	63°41'	135°51'	
<b>Rivière Grandin, 86 D</b>			
<i>(Adopted October 2, 1958)</i>			
Beaverlodge Lake	64°42'N.	118°11'W.	
Stairs Bay	64°47'	118°14'	
Agira Lake	64°38'	119°00'	
Leonforte Lake	64°35'	119°38'	
Messina Lake	64°11'	119°31'	
Ortona Lake	64°46'	119°12'	
Dennison Lake	64°42'	118°50'	
Rome Lake	64°19'	118°20'	
Lac Malfait	64°37'	118°01'	not Malfait Lake
Etna Lake	64°27'	119°28'	not Aetna Lake
Cassino Lake	64°05'	119°24'	not Casino Lake

